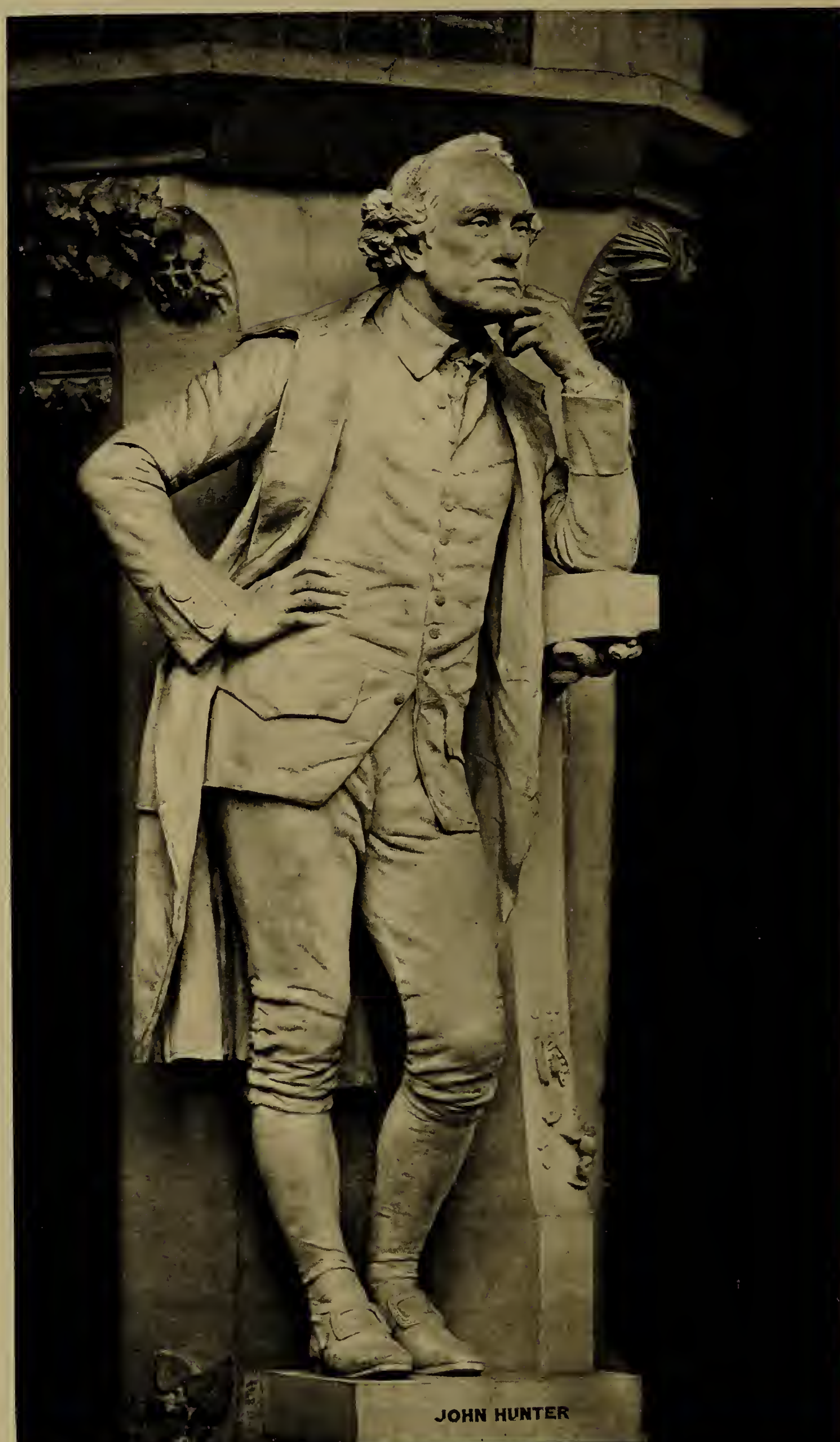
SOME APOSTLES OF PHYSIOLOGY

MDCCCCII.



Photogravure by Annan & Sons, Glasgow

SOME APOSTLES

OF

PHYSIOLOGY

BEING

AN ACCOUNT OF THEIR LIVES AND LABOURS

LABOURS THAT HAVE CONTRIBUTED TO THE ADVANCEMENT OF THE HEALING ART

AS WELL AS TO THE PREVENTION OF DISEASE

BY

WILLIAM STIRLING, M.D., Sc.D.

Brackenbury Professor of Physiology and Histology,
Owens College, Manchester,
Professor in Victoria University, Manchester.

This Copy is the Property of—

Henry S Wellcome Esq.

Privately printed at London by WATERLOW AND SONS LIMITED in the Year of Grace and Peace

1902.


VITA SINE LITTERIS MORS EST

TO

WALTER WHITEHEAD,

PRESIDENT

OF

THE BRITISH MEDICAL ASSOCIATION,

1902,

CONSULTING SURGEON TO THE ROYAL INFIRMARY, MANCHESTER,

LATE PROFESSOR OF CLINICAL SURGERY

IN THE VICTORIA UNIVERSITY AND THE OWENS COLLEGE,

WHOSE LOVE OF ART AND WHOSE LIBERALITY HAVE
MADE IT POSSIBLE TO ISSUE THIS VOLUME IN A
MANNER WORTHY OF THE EVENT IT
IS DESIGNED TO CELEBRATE.

MCMII.

FROM CAROLUS STEPHANUS, 1545.

TO THE READER.

I HAVE written this brief account of the lives of some of those who, directly or indirectly, have contributed to the advancement of Physiology, or, to use the old phrase, The "Institutes of Medicine," solely as a labour of love and in no sense as a task. For many years past in my lectures I have been in the habit of giving a short sketch of the lives and showing the printed works of some or most of these illustrious "Apostles," and of many of their colleagues. These notes as now printed are not intended to give a consecutive history of Physiology, but in arranging the subject-matter I have followed a roughly chronological sequence. All the portraits are of those who have joined the majority. The illustrations in the text are all taken from the originals in the works in which they occur. One plate I have added to illustrate the powerful, vigorous, and artistic treatment of dissections of the muscles by D. Bucretius, and the quaint, not to say picturesque, manner of treating the nervous system by C. Stephanus (d. 1564).

I have omitted much, especially on the recent discoveries on the central nervous system. So many

of those who have taken part in these advances, made practically within the last quarter of a century, are, happily, still with us, that I have left this question aside. I have dealt more with the past than with the present, and only here and there, and, as it were, incidentally, referred to some of the great living "Apostles."

I have endeavoured as often as possible to let the authors speak for themselves. The quotations are generally given in small type, with a reference to their source.

If I were to add a list of the works consulted, it would be a long list. I have to acknowledge my indebtedness to the writings of R. Willis, *Lectures on the History of Physiology*, by Sir Michael Foster, to some of the volumes of the *Masters of Medicine* series, *Medical Portrait Gallery*, by T. J. Pettigrew, *Biographisches Lexikon*, and the various *Histories of the Royal Society*. Most of the facts and quotations have been taken from the original sources.

Long years ago, in Ludwig's Laboratory, situated in the street then called Waisenhaus Strasse, now called Liebig Strasse, it was my good fortune to make the acquaintance of John Cleland, then of Galway, and now Professor of Anatomy in the University of Glasgow. *Imprimis*, to him my best thanks, because, through his friendship, I have enjoyed the privilege of increasing my knowledge of the works of the older Anatomists and Physiologists. Several of the illustrations are from works lent by him. Moreover,

Professor Cleland interested himself in the reproduction of the three photogravures, two of John Hunter and one of Vesalius.

I am indebted to Messrs. T. and R. Annan and Sons, Glasgow, for the superb manner in which they have executed these photogravures. The photogravure of what I venture to call "The Queen's John Hunter" is magnificent.

For the loan of prints, blocks, and medallions, I am indebted to my friends Mr. A. E. Shipley, and Dr. J. N. Langley, Professors Charles Richet and E. Gley, of Paris, Professors H. B. Dixon, De Burgh Birch, Sir J. Burdon-Sanderson, G. D. Thane, M. Verworn, Dr. R. Milne Murray, and to Professor Mariano L. Patrizi, of Modena. I have also to thank my friends Professor C. S. Sherrington and Professor A. D. Waller for help. Their contributions bear their initials. My thanks are also due to my old college friend Professor Arthur Thomson, of Oxford, and Mr. Horace Hart, for obtaining for me photographs from prints in the Hope Collection, and also to Mr. Victor G. Plarr for permission to obtain photographs of some of the rare prints in the Library of the Royal College of Surgeons of England.

For permission to copy certain illustrations I am indebted to A. H. Hallam Murray, Esq., Frank Bowcher, Esq., Sir W. Paget Bowman, Pierre Petit et Fils, Paris (to copy their portrait of Pasteur), Messrs. Mayall & Co., Limited, London, Frau Dr. A. M. Schubart, and to the Hon. John

Collier, who has allowed me to copy one of his portraits of HUXLEY.

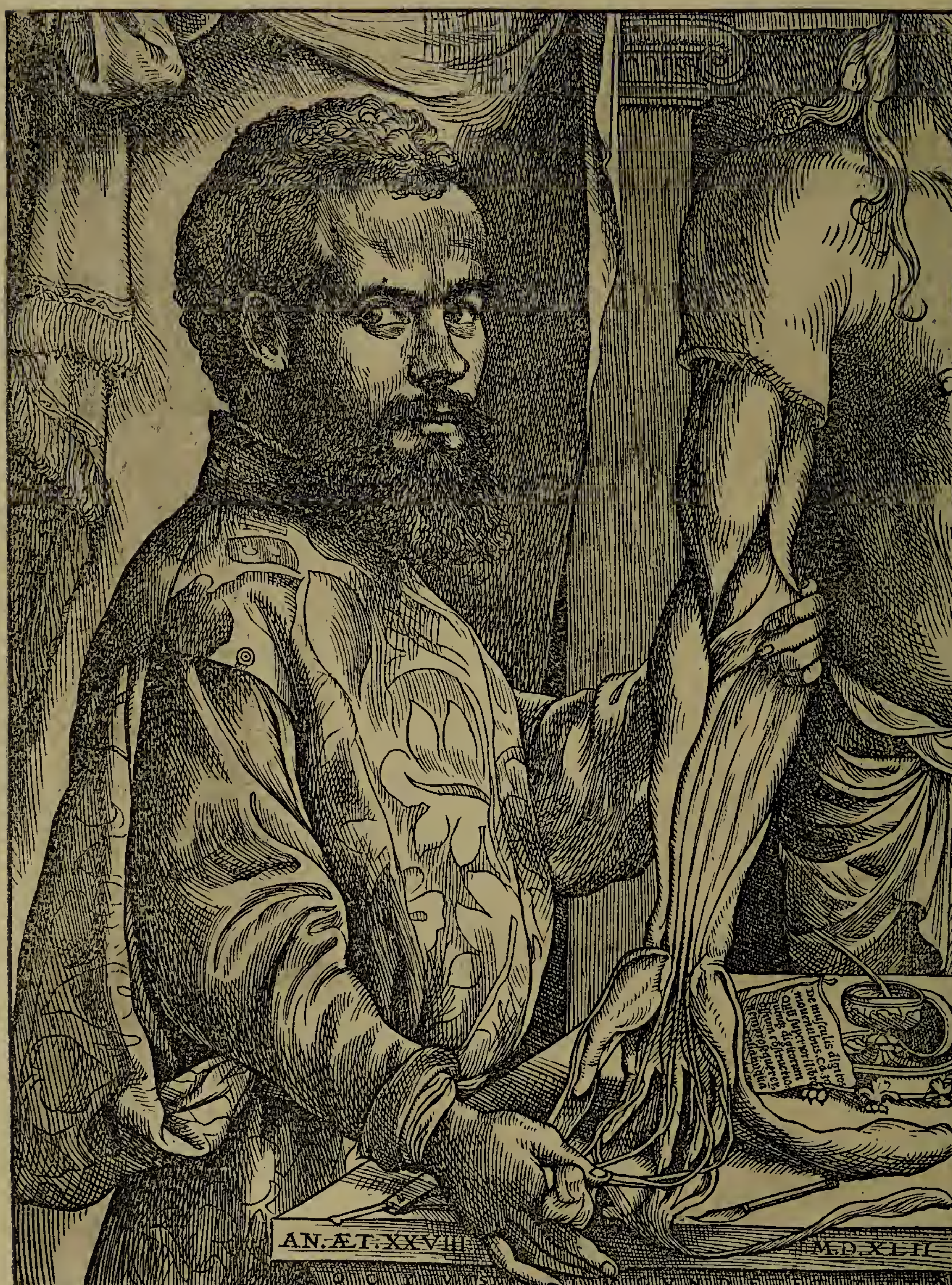
With a whole-hearted response, I say thanks to Messrs. Waterlow and Sons Limited. Without their cordial and energetic co-operation it would not have been possible to produce the work in the manner in which it has been, or in the short time, less than three months, available for printing and making the collotypes. All the collotypes and most of the illustrations in the text were done by them. A few of the illustrations in the text were done by the Northern Photo Engraving Company, of Manchester.

Lastly, I have to thank Mr. Walter Whitehead for his encouraging stimulation, put in the characteristic but terse phrase, "Peg away." I have done so during intervals snatched from the routine work of a rather busy session, and endeavoured to give as the result of his often repeated "minimum stimulus" the maximum response. In any case, like the heart, the response is the best that I am capable of, and my only wish is that the perusal of this work will give as much pleasure to the reader as its production has given to the writer.

WILLIAM STIRLING.

PHYSIOLOGICAL LABORATORY,
OWENS COLLEGE, MANCHESTER,
July 10*th*, 1902.

ANDREAE VESALII.



AFTER the writings of Galen, the next work of importance on anatomy is that of MONDINUS, who was Professor in Bologna, and died there in 1318. His written works were printed in 1478. One edition forms part of the *Fasciculus Medicinæ* of JOANNES Â KETHAM (1494). It has a woodcut, attributed to the Venetian School of Bellini, representing the anatomist dissecting the human body, which is, according to R. Willis, the first representation of the kind that exists. In the edition of his works with commentaries by Jacobus Carpus, *i.e.* Berengarius Carpus (Bonon. 1521)—a quarto of 527 pages—there is an excellent description of the heart and its valves—"Valvulas in vasorum cordis orificiis, ostiola vocat" (Douglas). The edition *Anatomia Mundini*, by Io. Dryandrum (Marpurgi 1537), consists of 67 pages, illustrated by several rather crude woodcuts.

FIRST KNOWN PICTURE OF AN ANATOMICAL DISSECTION.

The works of the "famous J. Berengarius of Carpus . . . adorned with many demonstrative figures," were "done into English by H. Jackson, Surgeon, London, 1644, pag. 376. *Cum Præfatione* D. Wharton." Perhaps it may be of interest to note that, according to Douglas, Berengarius was the first to describe the *appendix cæci*. Moreover, "Inunctionis ex Hydrargyro in cura Luis Venereæ primus fuit

inventor." Passing over the picturesque story of that learned physician FRANÇOIS RABELAIS (1483-1553), the immortal author of Pantagruel and creator of Doctor Rondibilis, we come to JACOBUS SYLVIUS—Jacques du Bois—who was born at Amiens in 1478, and died in 1555, æt. 77. Sylvius, from 1531, lectured at Paris to large audiences, and his fame as a lecturer attracted many students, including Vesalius. He succeeded the Florentine Vidus Vidius in the Chair of Medicine in the Collège de France, which was founded by François I. in 1529. He was an out-and-out Galenist, and taught that the veins carried the nutrient blood to the parts to be nourished. After his death his *Isagoge Anatomica*, or Introduction to Anatomy, was published. He described valves in veins, which he calls *epiphyses s. membraneas epiphyses*, at the orifice of the *vena azygos*, in the jugular, brachial, and crural veins, and was the first to use injections to trace the course of blood vessels. He also described the *foramen ovale*, and how it is closed several days after birth. He accurately described the *quadratus femoris* muscle, and gave names to particular muscles. He distinguished those muscles under the control of the will from those of automatic life. The latter he describes under the name of *villi* and includes the heart, stomach, and urinary bladder. His name is associated with the Fissure of Sylvius.

ANDREA VESALIUS.

1514-1564.

ANDREA VESALIUS, a native of Brussels, was born on December 31st, 1514—*dodrante post quintam matutinam.* His father was apothecary to the Archduke, afterwards Charles V. Vesalius studied at Louvain and Leyden, and proceeded to Paris in 1533, where he attended the lectures and demonstrations of Jacobus Sylvius and Guinterius (Joannes) of Andernach (1487-1574). Vesalius had been a pupil of Winter's at Leyden, when Winter taught Greek there. Winter became a lecturer on anatomy in Paris, and was physician to François I. He tells us that he had as his prosectors, "first, Andrea Vesalius, a young man, by Hercules! of singular zeal in the study of anatomy; and, second, Michael Villanovus (Servetus), deeply imbued with learning of every kind, and behind none in his knowledge of doctrine. With the aid of these two I have examined the muscles, veins, arteries, and nerves of the whole body, and demonstrated them to the students." Vesalius himself tells us how he learned his anatomy, and his method is still the only true one.

"My study of anatomy would never have succeeded had I, when working at medicine in Paris, been willing that the viscera should be merely shown to me and to my fellow-students at one or another public dissection by wholly unskilled barbers, and that in the most superficial way. I had to put my own hand to the business."

He did put "his own hand to the business," and thus became the Founder of Modern Anatomy.

The war between François I. and Charles V. compelled him to quit Paris and return to Louvain. He served as a surgeon with the Imperial troops in Flanders from 1535 to 1537. In 1537 he set out for Italy, and lectured at Pisa, Bologna, and elsewhere. The fame of his prelections—for before this time he had published little besides a translation of Rhazes—led to his appointment by the Republic of Venice to conduct the public dissections, and to the Professorship of Surgery in the University of Padua, which belonged to Venice. Under the powerful influence of the Senate of the Republic, Vesalius was able to obtain in Italy a more liberal supply of "material" for his life-work than was possible, perhaps, in any other part of Europe. Appointed to these high offices when he was about three-and-twenty years of age, he served the Republic for nearly seven years. The work he did must have been enormous, for in 1542 he dedicated his famous work *De Humani Corporis Fabrica* to Charles V. This great work *On the Structure of the Human Body,* a folio of 659 pages with illustrations by John Calcar, and not by Titian, was published in 1543 at the printing press of J. Oporinus (or Herbst) in Basel. The manuscript was completed in 1542, when Vesalius was æt. 28, as shown in the famous portrait of him here reproduced by photogravure. Notice that it bears a quaint form—"OCYUS IVCVNDE ET TVTO"—of the old motto.

The publication of his great work—which marks at once the beginning of modern anatomy and laid the basis for the study of physiology—brought to Vesalius the uncompromising hostility of the Galenists of his day. The book recorded the results of Vesalius' own labour, his direct appeal to nature—to what he calls the only true bible. His master Sylvius, his pupil Columbus, his successor Falloppius (1523-1563), and others wrote against his teaching. He seems to have been discouraged thereby. There were probably other reasons which led him to quit Padua, on whose University he had conferred immortal fame, and in which he had acquired for himself lasting renown. It is stated that about this time an offer came from Charles V. inviting Vesalius to become his Court Physician. He accepted the offer and left Padua in 1544. Here ended the scientific career of Vesalius. Doubtless he witnessed that memorable scene on October 25th, 1559, at Brussels, when Charles with all suitable pomp, ceremony, and solemnity "surrendered to his son, Philip (II.) all his territories, jurisdiction, and authority in the Low Countries." Charles, "unable to stand without support," leaning on the shoulder of the Prince of Orange, spoke of himself as "a sovereign worn out with diseases, and scarcely half alive" (Prescott). A few weeks later he resigned to his son the Kingdom of Spain.

Vesalius was appointed physician to Philip II., and returned with him to Spain in 1559, just at the period when the Inquisition was in full activity. In Madrid "he could not lay his hand on so much as a dried skull, much less have the chance of making a dissection."

Along with Malatesta, in 1563, he made a pilgrimage to Jerusalem. On his way he stopped at Venice, where he learned that his pupil and successor Gabrielo Falloppio (Falloppius) had died in 1562. It is said that Vesalius was invited by the Venetian Senate to return to his Chair; on his way back from the Holy Land, he fell ill and was put ashore at Zante or Crete and there he passed away in 1564. One account states that he was shipwrecked and perished of hunger. A second edition of the *Fabrica* was published in 1555, but the eulogium on Jacobus Sylvius, which found a place in the first, finds no place in this. Vesalius observed for himself, and set up the method of direct ocular inspection and exact observation as a method of inquiry—he appealed to nature, and not to the doctrines or authority of individuals, at least so far as anatomical facts are concerned. His anatomy was that of the human body, and the result of his own labours, but his physiology was that of Galen. Galen proved by experiments on living animals that the arteries contain blood and not air. He showed that the left side of the heart during life contained blood of a scarlet colour—he called it "pneumatized" blood. It was already known that the right side of the heart and the vessels connected with it contained venous blood. How does the blood get from the right to the left side of the heart, and how do the veins communicate with the arteries? Galen had a general notion that veins and arteries did communicate by "anastomoses." The veins took origin from the liver, drawing their blood thence and distributing it over the body—a very natural supposition, when we trace the course of digested food from the intestine by the *vena portæ* to the liver, where the blood was "concocted" before it entered the great *vena cava* to be distributed over the body. But on the complex Galenic theory all the blood was not distributed by the veins to the body, some—a very small part—was supposed to pass to the lungs by the pulmonary artery (*vena arterialis*) and there gave off some "fuliginous" vapours and at the same time took in something which Galen called "pneuma." Some of the blood thus concocted and altered was supposed to pass by the *arteria venalis* (*i.e.*, the pulmonary vein) to the left heart, there to be further perfected into "vital spirits." The rest of the blood, he thought, passed directly through the septum of the heart, through the pits or depressions which exist there. Galen regarded them as holes. This blood, mixed in the left heart with the small amount of pneumatized blood coming from the lungs, was then distributed by the arteries. Both systole and diastole were regarded as active movements, the diastole being active in sucking blood into the heart.

VESALIUS DEMONSTRATING

Vesalius saw clearly enough that there was no visible direct passage from the right to the left side of the heart.

" The septum of the ventricles . . . abounds on both sides with little pits impressed in it. Of these pits, none, so far at least as can be perceived by the senses, penetrate through from the right to the left ventricle, so that we are driven to wonder at the handiwork of the Almighty, by means of which the blood sweats from the right into the left ventricle, through passages which escape human vision." (M. Foster's Lectures.)

In the last chapter of his work, which contains a curious figure of a pig fixed to an operating table, he tells us that an animal can live without its spleen; that the brain acts on the trunk and limbs through the spinal cord; that section of the recurrent laryngeal nerve —lateral to the *soporales arterias*—results in loss of voice; that the lungs shrink or collapse when the chest is punctured. He was the first to perform artificial respiration in animals. He found that an animal can be kept alive by artificial respiration, even if its chest is completely opened.

MICHAEL SERVETUS.

1509-1553.

MIGUEL SERVEDE was born in 1509 or 1511, in Villanueva, in Aragon. He was educated for the Church, and studied at the Universities of Saragossa and Toulouse. In Toulouse he studied law; but, says Willis, " law was never the subject that engrossed the thoughts of Servetus. The natural bent of his mind, and the teaching he received, led him to theology." " Servetus possessed the character of the enthusiast to perfection." In 1531 he published *De Trinitatis Erroribus*, or *Seven Books on Mistaken Conceptions of the Trinity*. He was a pioneer of the Unitarian doctrine. The facts regarding the name of the printer and the place where it was printed only came to light when Servetus was on his trial in Geneva in 1553. This work, instead of bringing him support and fame amongst the German and Swiss reformers, had exactly the opposite effect. He went to Paris in 1532, where he was known as Michael Villeneuve, or Villanovanus.

" It was during his first sojourn of about two years at Paris—1532–1534—that he made the acquaintance of the man who became in the end his most implacable enemy, and the immediate cause of his untimely and cruel death. This was none other than John Calvin." (R. Willis.)

He quitted Paris and went to Lyons, where he became reader for the press for the famous typographers Trechsel. Books at that time were generally printed in Latin, and it is obvious that a reader for the

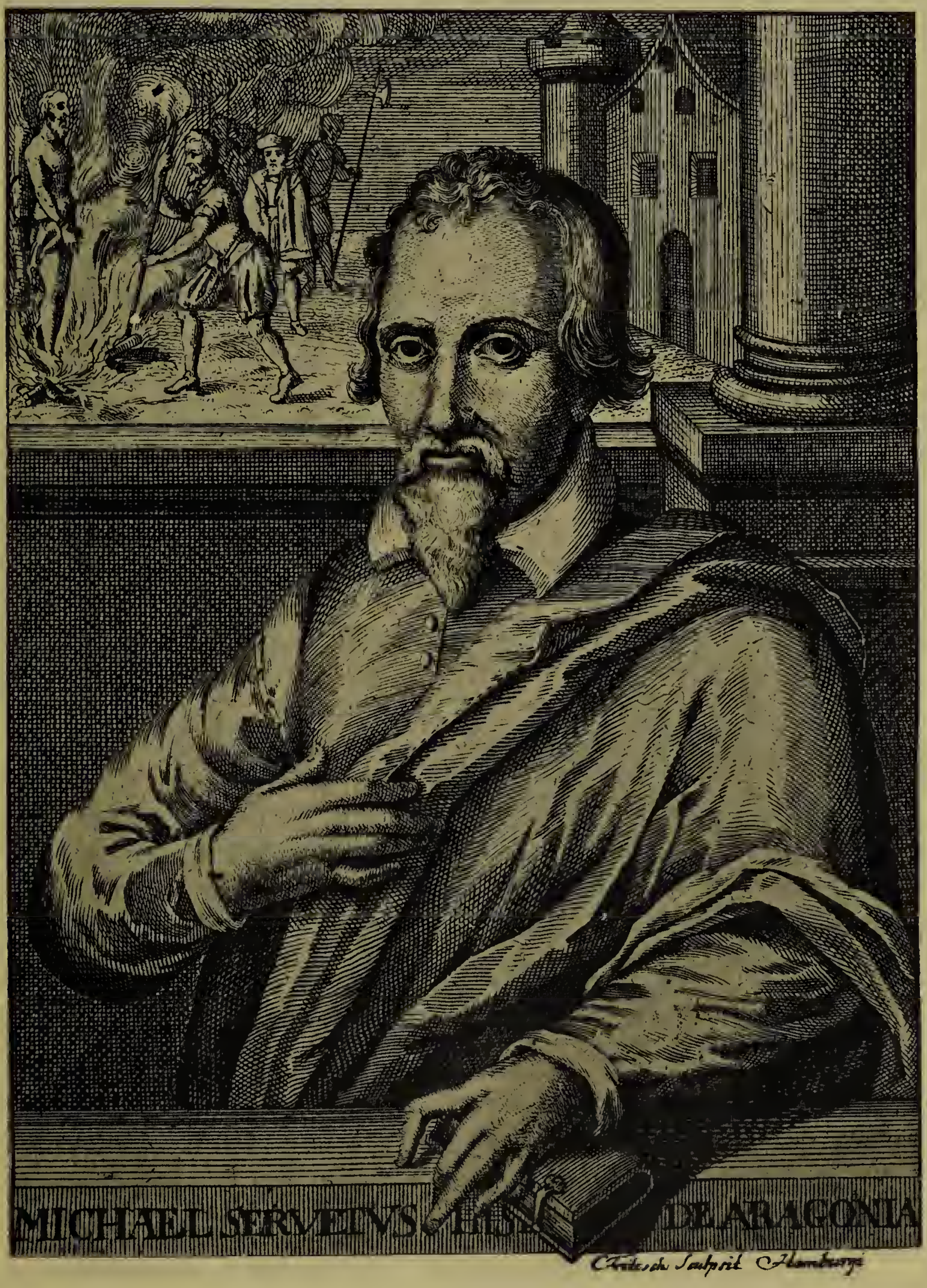
press must be a scholar and a man of letters, well grounded both in Latin and Greek. He edited many costly works, including an edition of the *Geography of Ptolemy*, 1535. After a stay of about two years in Lyons his thoughts were directed to medicine, and he returned to Paris and studied, as already stated, under Sylvius, Guinterius, and Fernelius. In Paris he wrote a work on *Syrups*, lectured on geography and astrology, and practised medicine for a short time. He left Paris and practised medicine under the name of M. Villeneuve at Vienne, near Lyons, in Dauphiny, for twelve years.

It is plain, however, that his mind dwelt more on matters theological than medical. During this period he wrote the famous work *Christianismi Restitutio* or *The Restitution of Christianity*. A copy in MS. was sent to Calvin and also to Curio. It was in MS. in 1546. It does not appear that the work was freely circulated; indeed, Calvin had difficulties in obtaining the copies required for the prosecution of Servetus.

In the fifth book, which treats of the Holy Spirit, he introduces the following passage (quoted as translated by R. Willis), which shows, without doubt, that he, Servetus, rejected absolutely the idea of the passage of blood from the right to the left side of the heart through the septum. He had grasped the true features of the pulmonary circuit. After speaking of the natural, vital, and animal spirits of the heart as the first organ that lives, and as the source of the heat of the body, of the liver sending to the heart the liquor, the material, as it were, of life, he shows how this material is elaborated by a most admirable process, thus it comes to pass that the life itself is in the blood—yea, that the blood is the life, as God himself declares (Genesis ix., Leviticus xvii., Deuteronomy xii.).

> "The first thing to be considered is the substantial generation of the vital spirit—a compound of the inspired air with the most subtle portion of the blood. The vital spirit has, therefore, its source in the left ventricle of the heart, the lung aiding most essentially in its production. It is a fine attenuated spirit, elaborated by the power of heat, of a crimson colour and fiery potency—the lucid vapour, as it were of the blood . . . . engendered by the mingling of the inspired air with the more subtle portion of the blood which the right ventricle of the heart communicates to the left. This communication, however, does not take place through the septum, partition, or midwall of the heart, as commonly believed, but by another admirable contrivance, the blood being transmitted through the pulmonary artery to the pulmonary vein, 'et a venâ arteriosâ in arteriam venosam transfunditur,' by a lengthened passage through the lungs, in the course of which it is elaborated and becomes of a crimson colour. Mingled with the inspired air in this passage, and freed from fuliginous vapours by the act of expiration, the mixture being now complete in every respect, and the blood become a fit dwelling place for the vital spirit, it is finally attracted by the diastole, and reaches the left ventricle of the heart."

He remarks on the great size of the pulmonary artery, its various conjunctions in the lungs with the pulmonary vein within the substance of the lung, as showing that so large a stream of



MICHAEL SERVETUS.

blood would not pass to the lungs for their nourishment only. The lungs of the fœtus are otherwise nourished. The mixture of blood and air takes place in the lungs, not in the heart, and it is in the lungs that the florid colour of the spirituous blood is acquired.

R. Willis, the biographer of Servetus and Vesalius, justly remarks that—

> " Vesalius, the observer, abiding by the concrete, describes with rare fidelity and truthfulness what he witnessed : Servetus, gifted with genius, aspiring to the ideal, and inferring consequences, deduced the pulmonary circulation from the structure of the heart and lungs."

(*Servetus and Calvin*, by R. Willis, M.D., 1877, p. 106.)

There is, however, no idea of a circulation in the sense in which we now understand it. To Servetus the liver and the veins connected with it were the great organ for the growth and nourishment of the body.

> " The heart was the source of the heat of the body, and, with the concurrence of the lungs, the elaboratory of the vital spirits ; the arterial system in connection with it being the channel by which the spirit that gives life and special endowment to the bodily organs is distributed."

Servetus's book remained unknown in the Republic of Letters until it was unearthed by Wotton in his *Reflections on Antient and Modern Learning*, in 1694, a century and a half after the death of its author.

The rest of the story is soon told. Calvin denounced Servetus to the ecclesiastical authorities of Lyons and Vienne. He was arrested, but probably was allowed to escape from Vienne, only to fall into the hands of his implacable antagonist in Geneva. It is not necessary to dwell on the so-called trial. Every one knows how at the bidding of Calvin, on October 27th, 1553, Servetus was burned at the stake because he would not retract his religious opinions. With him was burned nearly the whole edition—one thousand copies—of his *Restitutio*—in fact, all save a few copies. He is reported to have said : " Will not the flames make an end of my misery ? Is it not possible for them to burn me quickly by buying wood enough with the hundred golden pieces and the costly chain they took from me ? "

REALDUS COLUMBUS—or Colombo—a native of Cremona, born 1516, died at Rome 1557, was for a short time the deputy of Vesalius at Padua, and for two years his immediate successor. In his *De Re Anatomica* Libri XV., published at Venice in 1559, after his death, there is an account of the course of the blood through the lungs, or the pulmonary circulation. To Columbus the liver is still the *fons, origo, et radix*—the head, fount, and origin—of all the veins ; the heart is not a muscle. There is something unsatisfactory

about his claims to originality. Indeed, it is probable "he had no title to originality of any kind." (R. Willis.)

AMONGST the anatomists of the sixteenth century, after Vesalius, BARTHOLINUS EUSTACHIUS, who was born at San Severino, is, perhaps, the most distinguished. His name is still preserved in anatomical story by the terms Eustachian tube and Eustachian valve. His physiology was entirely Galenic. He was Professor of Anatomy at Rome, where he died in 1574. The plates of his work on anatomy were engraved in 1552, but Eustachius was too poor to publish them. Indeed, they were only brought to light and published by Jo. Maria Lancisius—who was *Intimus Cubicularius, Archiater Pontificis* to Pope Clement XI.—under the title *Tabulæ Anatomicæ,* in 1714. The following woodcut is taken from this work :—

Eques Petrus Leo Ghezzius Inu. et delin.

ANATOMICAL THEATRE FROM EUSTACHIUS.

The plates themselves have an engraved scale at the sides. J. Douglas, in his *Bibliographiæ Anatomicæ Specimen,* &c., as usual, in italics, brings out certain salient features. Eustachius saw the thoracic duct in the horse, but did not recognise its importance.

"Ductum thoracicum quem in venam, referre albam instructam ostiolo semicirculari intra venam jugularem internam hiante."

"Valvulam orificio venæ in corde coronalis præpositam primus omnium observavit."

"Valvulam in vena cava prope cordis auriculam dextram ut suum inventum prædicat [see Sylvius] eamque exactissimè describit."

GABRIEL FALLOPPIUS, born at Modena in 1523 (Douglas gives 1490), died at Padua 1563, was called from Pisa to Padua to occupy the Chair of Vesalius, but he held it only for two years. He was prosector before Vesalius was appointed. He was a great

anatomist, "in docendo maxime methodicus, in medendo felicissimus, in secando expeditissimus," but a very adverse critic of Vesalius. His name is still preserved in anatomical lore by the aqueduct and tube of Falloppius.

IN many respects ANDREAS CESALPINUS, of Arezzo (1519-1603), naturalist, philosopher, and physician, presents an interesting psychological study. He first used the term *circulatio*, as applied to the passage of the blood from the right to the left side of the heart, but does not mention Columbus in his *Quæstionum Peripateticarum* Lib. V., ed. 1593. He describes the systemic circulation, and how the veins swell on the far side of a ligature. It is impossible to say how far his views were merely controversial statements or the outcome of patient investigation. One thing is certain, that they had little if any influence upon his great contemporary Fabricius. He wrote an excellent work on *Plants*, and, in some respects, laid the foundation for Linnæus. He was Professor of Medicine and Botany in Pisa (1567-1592); then he went to Rome, to the Collegio della Sapienza there, and became Archiater, or physician, to Pope Clement VIII. His chief work, *Peripatetic Questions* (1571), deals with the philosophy of Aristotle, speculative physiology. He was a theorist rather than an experimenter, and held curious views regarding the invisible demons that, according to him, ruled the world.

HIERONYMUS FABRICIUS.

1537–1619 (æt. 82).

FABRICIUS was born in the Tuscan village of Acquapendente, studied at Padua, and succeeded his master, Falloppius, in the Chair of Anatomy and Surgery in 1565, a post which he held until his death. He was not only a great anatomist, whose renown attracted many students—amongst others, W. Harvey—to Padua, but he was also a great surgeon. His work on surgery contains several plates, showing some of the extraordinary mechanical contrivances in use by surgeons in those days. He also wrote on vision, voice, and hearing, and of the organs or "instruments" thereof. He gives admirable plates of the development of the chick in the egg—*De Formatione Ovi et Pulli*—a work also which later engaged the last years of his pupil, Harvey. In his treatise *De Respiratione* (1599-1603), he deals with the muscles and mechanisms or "instruments" of respiration, and the purpose of respiration. As regards the circulation of the blood, he practically taught what Galen taught. His work on the valves in the veins,

is entitled *De Venarum Ostiolis* (Petav. 1603). He wrote as if he believed he was the first to discover these *ostiola,* or little doors, when dissecting in 1574.

"Who, indeed, would have thought of finding membranes and ostiola within the cavities of the veins, of all places else, when their office of carrying blood to the several parts of the body is taken into account?" "The ostiola," he says, "were contrived by the Almighty Maker of all things to prevent over-distension. They are most numerous in the extremities, because of the violent motions to which they are exposed . . . . and the blood, by reason of the increased heat, is attracted, and flows towards the extremities in excessive quantity."

Their chief office, however, is to retard the flow of blood, and thus give time for the tissues to select from the blood the nutriment most suited for them. There were no valves in the arteries, which had thick and strong walls, and were not liable to distension. That valves are absent in some great veins connected with important organs is to allow free access of blood to these organs. The figure we have reproduced shows the arm bound with a fillet, as for bleeding; the veins are swollen, and the position of the valves indicated by slight bulgings, exactly as was figured by Harvey. The other figure shows an everted vein, with its valves. In the original there is a sprig of verbena. How different the uses made of the same

FROM FABRICIUS, SHOWING VALVES AND VEINS.

fact by master and pupil! Fabricius used the fillet to show the position of his ostiola, Harvey to show that, owing to their presence, the blood could not flow from trunks to branches, as the swelling occurs below the ligature. The quotations already given show how the theories of Galen still held the field, and were taught by the most advanced teacher of anatomy, at a period just before Harvey observed, experimented, and wrote.

Fabricius was greatly respected in the Republic of Venice. The illustration we have chosen is the frontispiece to his works, and shows him with his gold chain as a Cavaliere di San Marco, the chain probably presented to him as a mark of respect by the Senate of Venice. His good services to the State were rewarded with a pension. The learned and somewhat erratic G. Ceradini (1844–1894), who took a deep interest in the writings of the Italian

FABRICIUS AB AQUAPENDENTE.

JULIUS CASSERIUS.

anatomists of the sixteenth century, says that Fabricius appears "not to have had even the most remote idea of a circulation of the blood." If Fabricius had not, who had?

JULIUS CASSERIUS.

1545–1605.

CASSERIUS was sometimes called Placentinus, from the place of his birth. By Douglas he is described as "philosophus, medicus, chirurgus et anatomicus pereximius." Born of humble, not to say poor, parents, he became the *famulus* of Fabricius at Padua; from *famulus, auditor*, and, from *auditor, discipulus*, until he became a Professor in the University of Padua, at the time of Harvey. He has a certain quaint, not to say picturesque, way of setting forth his views of structure, that one would have liked to illustrate more fully. His work contains excellent figures of the organs of sense in many animals.

WILLIAM HARVEY.

1578-1657.

HARVEY was born at Folkestone on April 1st, 1578—eighteen years after Lord Bacon, one year after Van Helmont, and just four years after the publication by Fabricius of his work on the *Ostiola*. Proceeding to Cambridge he took his degree in Arts in 1597. In those days Padua was one of the great centres of intellectual activity, and its medical school was famous. Harvey proceeded to Padua, studied under Fabricius, and took his degree of Doctor of Medicine there in 1602—which entitled him "to practise and to teach arts and medicine in every land and seat of learning." On his return to England he was incorporated as an M.D. in Cambridge, became a member of the Royal College of Physicians in 1604, and a fellow in 1607. He was appointed physician to St. Bartholomew's Hospital in 1609. At the age of thirty-seven he was appointed, in 1615, by the College of Physicians, Lecturer on Anatomy, *i.e.* to the lectureship founded by Drs. Lumley and Caldwell. In 1616 he enunciated his views on the movements of the heart and of the blood. It was not, however, until 1628 that he published his famous work, *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus*, or *An Anatomical Disquisition on the Motion of the Heart and Blood in Animals*. It is a small quarto of about 80 pages, and

was published at "Franckfort" on the Main, then the great centre of the book trade. It was dedicated to Charles I. :—

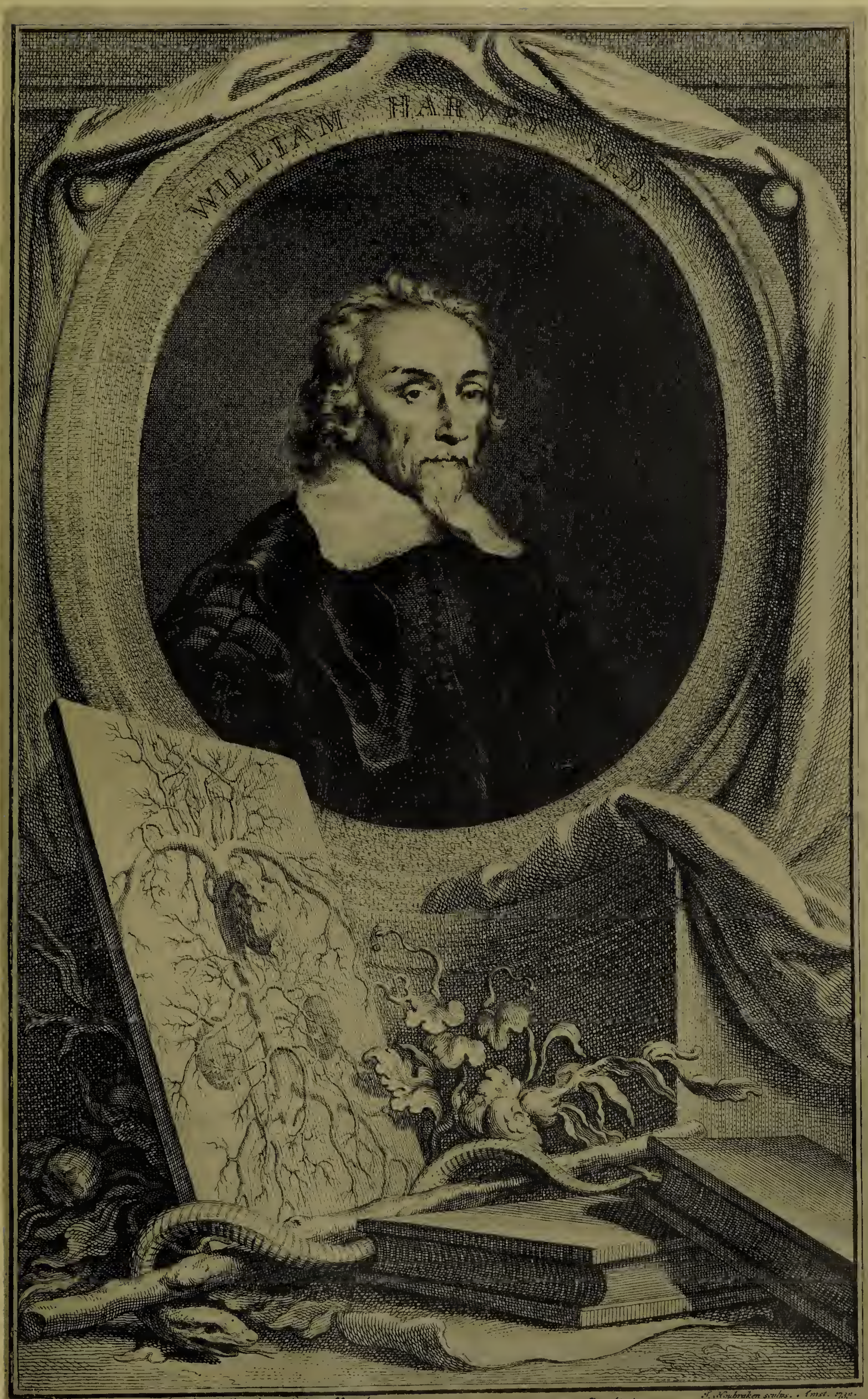
"Most Serene King! The heart of animals is the foundation of their life, the sovereign of everything within them, the sun of their microcosm, that upon which all growth depends, from which all power proceeds. The King, in like manner, is the foundation of his kingdom, the sun of the world around him, the heart of the republic, the fountain whence all power, all grace doth flow. . . . . ."

The MS. of Harvey's lectures, bearing date 1616, was reproduced in autotype by a committee of the Royal College of Physicians of London, in 1886, under the title *Prælectiones Anatomiæ Universalis*. This *annus mirabilis* marks also the death of Shakespeare.

"The object of the publication was to present and make public the original notes of the lectures in which Harvey, in 1616, set forth for the first time his discovery of the circulation." "It was from Aristotle, he says, that he obtained the first direction to the true explanation of the movements of the heart, and he quotes the father of science more often than any other author. Galen comes next in the order of frequency of quotation; while of the moderns Vesalius, Columbus, Falloppius, Fernelius, Laurentius, Nicholaus Massa, Bauhin, and Piccolhomini are the writers whose opinions he most often discusses. In classical literature he had read Plautus as well as Virgil and Horace. . . . . He was learned in the Scriptures, and knew something of the Latin fathers." "He had dissected animals of all kinds, and refers to the anatomy of more than eighty."

In 1632 Harvey was appointed physician to Charles, and became his devoted friend. Charles showed a decided taste for art and encouraged the study of the sciences. He placed at Harvey's disposition the deer in the Royal parks, which helped him to prosecute his researches in embryology. As physician to the King, Harvey was present on Sunday, 23rd October, 1642, at the battle of Edgehill, and every one knows the account given by Aubrey, how with the two boy princes, the Prince of Wales and Duke of York, under his charge—the elder was afterwards Charles II., the younger James II. —he withdrew with them under a hedge reading a book. It is even suggested that the book was his favourite treatise of Fabricius upon generation. He accompanied the King to Oxford, and Aubrey says that during his brief stay here "I remember he came several times to our College (Trinity), to George Bathurst, B.D., who had a hen to hatch eggs in his chamber, which they opened daily, to see the progress and way of generation."

Harvey remained in the service of the King until 1646, when feeling the effects of age—he was already sixty-eight and sorely tried by repeated attacks of gout—he retired into private life. Five years later, in 1651, he published his second great work, *De Generatione Animalium*. He died in 1657, æt. 79, and was buried at Hempstead in Essex. Harvey died without issue, and his wife predeceased him. He gave the College of Physicians the value of his paternal estate to pay the salary of the librarian, and for an annual



WILLIAM HARVEY.

commemoration address, now known as the Harveian Oration. Harvey did more than discover the circulation of the blood; he demonstrated, by the experimental method, that the blood moves in a circle, that the movement of the blood is due to the mechanical action of the heart as a pump, that systole is an active contraction of the heart and diastole a passive act of dilatation. He gave a true theory of the pulse. For all time he set the method, viz., that of experiment and induction, which has led to all modern progress in physiology. He tells us both his motives and his methods.

"When I first gave my mind to vivisections, as a means of discovering the motions and uses of the heart, and sought to discover these from actual inspection and not from the writings of others, I found the task so truly arduous, so full of difficulties, that I was almost tempted to think, with Frascatorius, that the motion of the heart was only to be comprehended by God. . . . At length, and by using greater and daily diligence, having frequent recourse to vivisections, employing a variety of animals for the purpose, and collating numerous observations, I thought that I had attained to the truth. . . " (Chap. I.)

Although Harvey was quite clear that the arteries and veins do communicate, it was reserved for Malpighi, by the use of the microscope, in 1664—seven years after Harvey's death—to demonstrate on the lung of a frog the passage of the blood from arteries into veins by means of the capillaries.

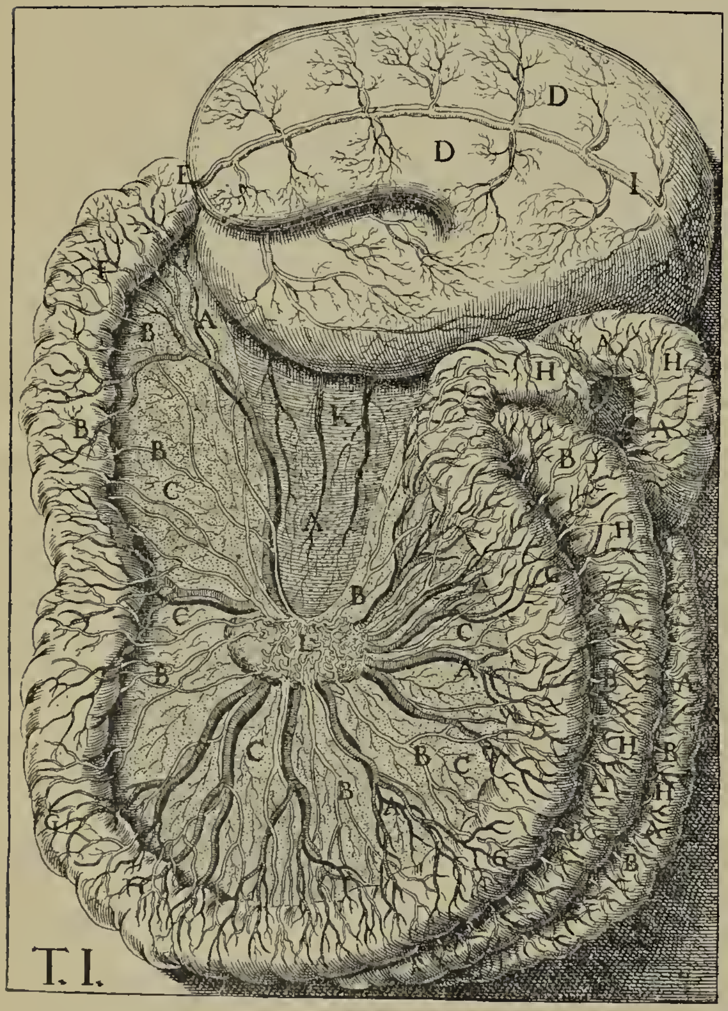
GASPAR ASELLI.

1580-1626 (æt. 46).

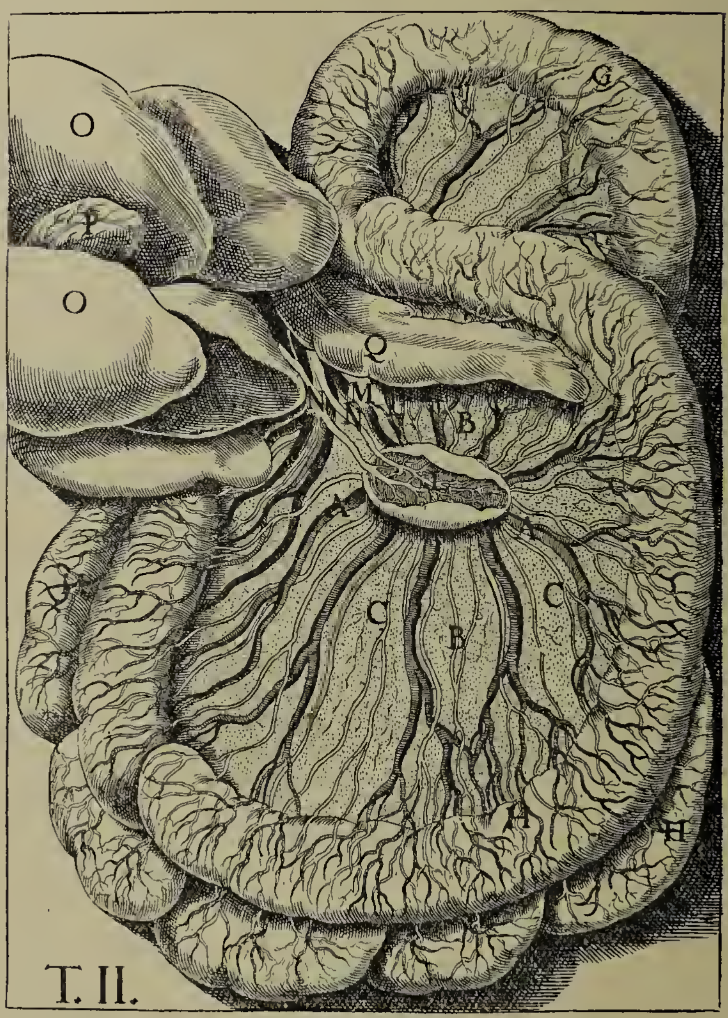
UP to nearly the end of the first quarter of the seventeenth century the only vessels known to Anatomists were arteries and veins. There was born at Cremona, in 1580, one Gaspar Aselli, Professor in Pavia, and surgeon in Milan, who in 1622 accidentally made a great discovery, viz. the "lacteal veins" or lacteals. The work was published posthumously in 1627, through the liberality of Claude Nicolas de Pieresc, a Seigneur of the old régime and a patron of science,—under the direction of A. Tadinus and Senator Septalinus. These colleagues of Aselli were witnesses of the original discovery. The work is entitled *De Lactibus sive lacteis Venis* &c. *Dissertatio* (Mediolani 1627). Besides the four remarkable plates, with the white lacteals on a red ground, the natural colour of the parts, it contains the portrait of the author here reproduced, which is taken from the copy of this work in the Library of the Royal College of Surgeons of England. It is said to be the first work in which block printing is used for the purpose of illustration.

Aselli tells us how he made the discovery accidentally on July 23rd, 1622. While dissecting a dog, which had been fed a few hours

before and was therefore in full digestion, to show the recurrent laryngeal nerves, and the movements of the diaphragm, he saw a network of white tracts in the mesentery. He at first thought they were nerves. He punctured one, there flowed out a white liquid—the chyle. In a transport of joy he, like Archimedes, cried out "Eureka !" He had discovered the lacteals. He traced them to the group of mesenteric glands still known as the "pancreas Aselli." He thought they went to the liver, and thus failed to trace their true ending. He recognised the presence of valves in these vessels and showed that they prevented a backward flow. They were seen by Asellius and others, including Bartholinus, both "in living animals, and men newly hanged and choaked." Bartholinus in his quaint way describes how he saw the "milkey veins in the body of Sueno Olai, who was choaked with a piece of tongue, having before eaten and drank plentifully, because respiration being hindered by the bit of tongue and his heart being suffocated, there was no necessity for the liver to draw any chyle." Indeed, Bartholinus believed them to pass to the Spigelian lobe of the liver.



PANCREAS ASELLI (L) AND LACTEALS (B) CONVERGING TO IT.



ASELLI'S FIGURE SHOWING LACTEALS PASSING TO THE LIVER.

FOLKESTONE and Dieppe are not so far apart—the one the birthplace of Harvey, the other of JEAN PECQUET (1622), the discoverer of the *receptaculum chyli* and its continuation as the thoracic duct. Pecquet announced his discovery in his *Experimenta nova*

WM. HARVEY.

G. ASELLI.

R. LOWER.

Anatomica (Paris 1651). He tells us that whilst studying at Montpellier as a pupil of Vesling in 1648, he left that "mute and frigid science" anatomy, and betook himself to the study of true science, organs in action. Whilst experimenting on a dog, he removed the heart, when he saw, amidst the blood in the pericardium, a white fluid, which at first he mistook for pus. He soon saw that it was chyle, that it came from a tube or canal which ended at the subclavian vein, that the duct—thoracic duct—began in a kind of reservoir or pouch, *receptaculum chyli*—that all the lacteals pass to it, and not to the liver. Chyle therefore does not go to the liver. He describes accurately the "lacteal veins" of Aselli, shows that they end in the *receptaculum chyli*, and that the thoracic duct pours its contents into the venous system at the junction of the jugular and sub-clavian veins. J. VAN HORNE, a year later, made the same discovery quite independently and published it in his *Novus Ductus chyliferus* (Lugd. Bat. 1652). Pecquet died at Paris in 1657, from an over-dose of brandy, a medicine which he regarded as a panacea for all ills.

IN 1650, OLAUS RUDBECK (1630–1702), Professor of Anatomy and Botany in Upsala, published his *Nova Exercitatio Anatomica exhibens ductus hepaticos aquosos et vasa glandularum serosa*. He describes the course of the lacteals towards a common trunk, unaware of the discovery of Pecquet. He demonstrated his results to Queen Christina in 1652. Whilst searching for this vessel he saw, on the liver, vessels provided with valves, containing a clear watery fluid. He took them for vessels quite distinct from the lacteals (1650–51), and called them *vasa serosa*, and traced them to the *receptaculum chyli*. He founded the first Botanical Museum, and the genus "Rudbeckia" is named after him. According to Glisson, an Englishman Jolive gave an account of these vessels about this time.

THOMAS BARTHOLINUS.

1616–1680.

IN Copenhagen, about the same time, T. BARTHOLINUS, Professor of Anatomy, son of Caspar B., was working at the same subject, and he, in 1651–52, discovered that *vasa serosa* were to be found in all parts of the body, and that they passed to the *receptaculum chyli*. He called them "lymphatics." Thus lacteals and lymphatics had a common final goal, and lymph and chyle finally reach the heart *viâ* the thoracic duct. We need not

enter here into the dispute between Rudbeck and Bartholinus on this matter. The quaint way in which Bartholinus gravely writes on the obsequies of the liver shows that he appreciated fully how recent discoveries had dethroned this organ from its high estate in the hierarchy of Galenic doctrine ; indeed, he gaily writes its epitaph. Still this mighty organ retains a mass of undiscovered secrets ; and, indeed, it was only in the middle of last century that Bernard elicited by experiment its profound influence in carbohydrate metabolism.

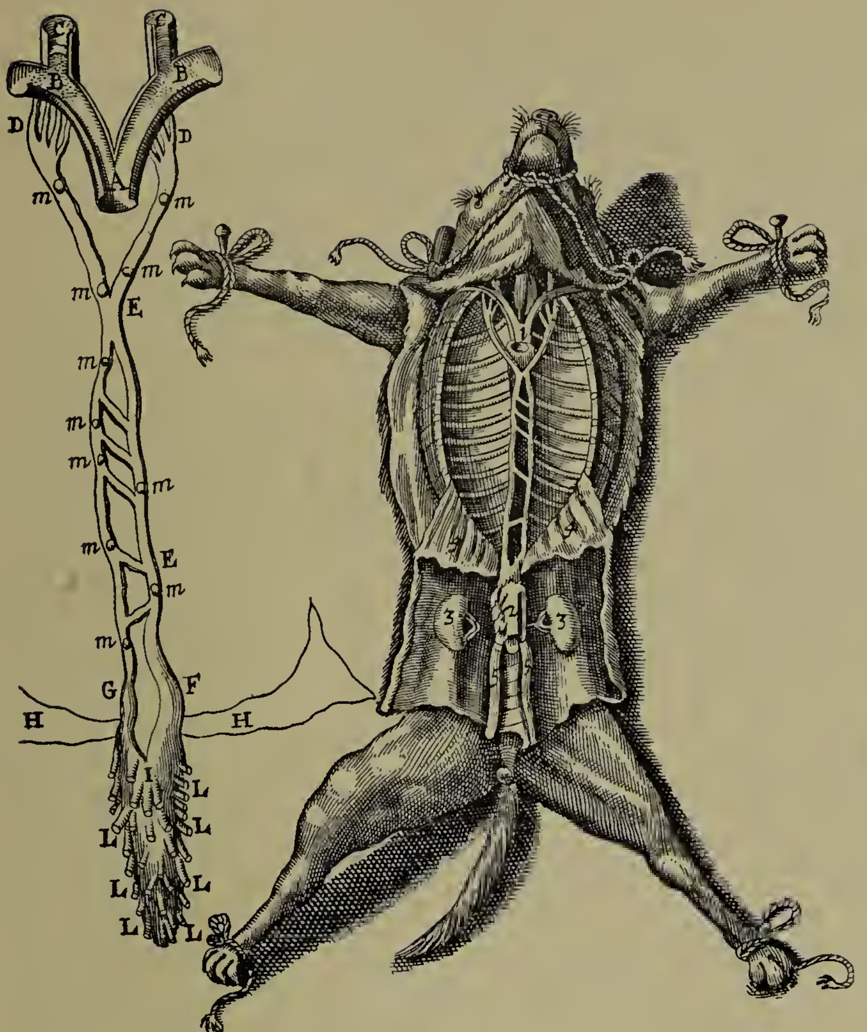
Be it noted that Aselli's work appeared in 1622, Harvey's in 1628, and that of Pecquet in 1651. Pecquet's observations were accepted at once, and now the whole anatomical structure was discovered for obtaining a proper view of the relation of the digestive system to the vascular system so far as regards the channels by which the products of digestion might reach the blood.

Pecquet of Dieppe, and Schlegel of Hamburg, and Joh. Walæus, were ardent supporters of the doctrine of Harvey. Pecquet shows how he had caught up the spirit of Harvey's work and had recourse to experiment to test the truth or otherwise of his views.

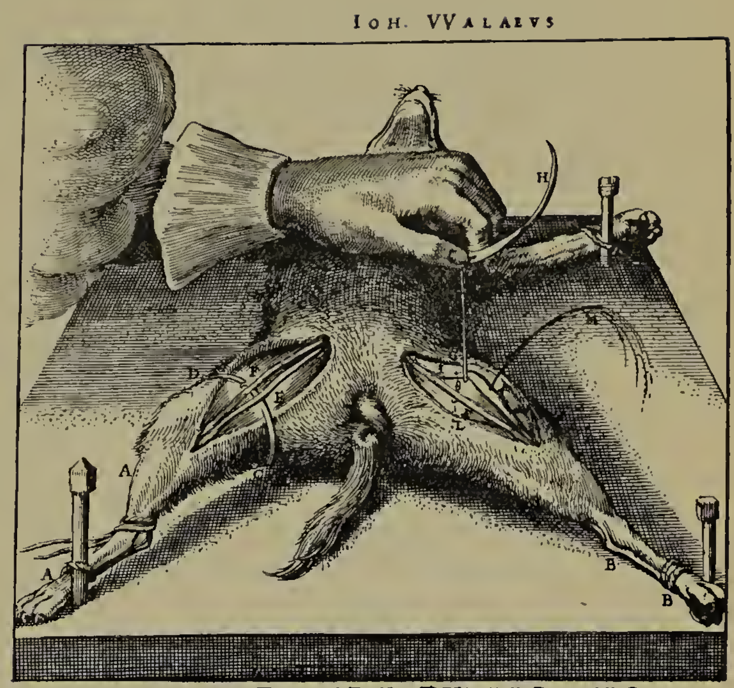
"Having exposed the artery and accompanying vein in the leg of a dog, and punctured the vein, blood, of course, immediately followed ; but tightening the ligature that had been passed round the artery, lo ! the stream from the vein ceased forthwith. Slackening the ligature, however, again it burst forth as before. . . . . Now if the blood flows outwards only by the arteries, did we tie the vessel which supplies a limb about to be amputated, the operation might be performed without loss of blood. No sooner imagined than put to the proof. I tied the crural artery of the dog, avoiding the vein, and amputating the member a little beyond the ligature. Only a few drops of blood escaped from the divided veins, but there was no hæmorrhage."

The influence of Bartholinus was great in Copenhagen. To him Stensen addressed his letters announcing his discovery of the duct of the parotid gland, and his dispute with Blasius, a former pupil of Bartholinus. Bartholinus began with the study of theology, and for nine years lived at other Universities. He graduated at Basel in 1645 under Bauhin, and in 1648 became Professor in Copenhagen, S. Paulli being induced for a consideration to resign his Chair to give place to the younger Bartholinus.

Among his pupils was JOH. WALÆUS (b. 1604), Professor in Leyden, 1633, who wrote two epistles *On the Motion of the Chyle and Blood,* to T. B., son of Caspar B. They show how he had grasped the importance of Harvey's doctrine, and he gives the following experiment, entitled *Dissection of a Vein in Living Creatures,* in support thereof. The woodcut explains itself. When the femoral vein is constricted by the thread passed round it the blood flows out, not in *guttæ* or drops, but as a *rivulus sanguinis qui, inferiori venæ parte vulnerata, continuo exilit.*



PECQUET'S FIGURE OF THE THORACIC DUCT IN THE DOG.



FIGVRÆ EXPLICATIO.

EXPERIMENT OF WALÆUS ON THE FLOW OF BLOOD IN THE FEMORAL VEIN.

The ligature "CD placed under the artery and vein which fast binds the thigh is shown in the right leg, lest the confusion of the lines might disturb the spectator in the left thigh."

Harvey's work, supplemented with the discovery of the capillaries and that of the lymphatic system, marks a new era in physiology. It revolutionized the whole subject, for now the examination of the exchanges between the blood of the organs and tissues of the body became possible. The idea of "spirits" ought to have disappeared, but it did not. The very title of his work suggests the wide view Harvey took of the problem; Harvey made accurate anatomical observations and planned experiments to test his hypotheses, and he made abundant use of his knowledge of comparative anatomy, and with convincing results.

"If a live snake be laid open, the heart will be seen pulsating quietly, distinctly, for more than an hour, moving like a worm, contracting in its longitudinal dimensions, (for it is of oblong shape,) and propelling its contents; becoming a paler colour in the systole, of a deeper tint in the diastole; and almost all things else by which I have already said that the truth I contend for is established, only that here everything takes place more slowly, and is more distinct. This point in particular may be observed more clearly than the noonday sun; the *vena cava* enters the heart at its lowest part, the artery quits it at its superior part; the vein being now seized either with forceps or between the finger and thumb, and the course of the blood for some space below the heart interrupted, you will perceive the part that intervenes between the fingers and the heart almost immediately to become empty, the blood being exhausted by the action of the heart; at the same time the heart will become of a much paler colour, even in its state of dilatation, than it was before; it is also smaller than at first, from wanting blood; and then it begins to beat more slowly, so that it seems at length as if it were about to die. But the impediment to the flow of blood being removed, instantly the size and colour of the heart are

E

restored. If, on the contrary, the artery instead of the vein be compressed or tied, you will observe the part between the obstacle and the heart, and the heart itself, to become inordinately distended, to assume a deep purple or even livid colour, and at length to be so oppressed with blood that you will believe it about to be choked; but, the obstacle removed, all things immediately return to their pristine state, the heart to its colour, size, stroke, etc." (Chap. X.)

Again, in this remarkable passage we have an experiment on a pigeon's heart that recalls those of modern times.

"Experimenting with a pigeon upon one occasion, after the heart had wholly ceased to pulsate, and the auricles too had become motionless, I kept my finger wetted with saliva and warm for a short time upon the heart, and observed, that under the influence of this fomentation it recovered new strength and life, so that both ventricles and auricles pulsated, contracting and relaxing alternately, recalled as it were from death to life." (Chap. IV.)

The end of the sixteenth and the beginning of the seventeenth century witnessed the marvellous discoveries in the new physics, although as yet there was but little exact chemistry. This is not the place to narrate the work of Torricelli and Galileo Galilei. The latter was called from Pisa in 1592 to become Professor in Padua, where he laboured until 1610. He died in 1642. Harvey went to Padua in 1598, so that he must have become acquainted with much of the "new learning." The seventeenth century also saw the foundation of associations or societies of individuals for the cultivation of the "New Philosophy" *i.e.*, experimental philosophy. The first society for the investigation of physical science was "Academia Secretorum Naturæ," founded at Naples in 1560, but it was soon dissolved by the ecclesiastical authorities. The "Accademia de' Lincei" was founded in 1603, of which Galileo was a member. It was dissolved owing to opposition from Rome. Shortly after Borelli went to Pisa, another society, "Accademia del Cimento," was founded at Florence in 1657 under the patronage of the Grand Duke Ferdinand II. Its members included many disciples of Galileo, Viviani the great geometrician, Castellio and Torricelli, and Borelli also was an active member. As regards membership, "all that was required as an article of faith was the abjuration of all faith, and a resolution to inquire into truth without regard to any sect of philosophy." The "French Academy" was established by Cardinal Richelieu in 1635; to England belongs the honour of being the first country after Italy to establish a society—the Royal Society—for the investigation and advancement of the "New Philosophy" in 1645. It is to be noted that medical men formed a large proportion of its members, Glisson and Ent were amongst its original members. It received the Royal patronage of Charles II. in 1663. In 1652 Leopold's Academy of Natural Science was founded. The corresponding French Royal Academy of Science was founded in 1666 at Paris by the Minister Colbert.

THE discoveries in physics soon reacted on the progress of physiology. A knowledge of these discoveries was rapidly propagated through these societies. There was one who wove the facts of the new physics into his conception of the universe and who exerted a profound influence on human thought, viz., RENÉ DESCARTES. He was born at La Haye in 1596, but spent the greater part of his life outside France, and died in Stockholm in 1650. We shall speak of him again in connection with the nervous system. Considering man as a machine, he tried to show how, just as the universe is a machine working according to physical laws, so also is man. An earthly machine, *machine de terre*, governed by a rational soul (*âme raisonnable*), which has its seat in the pineal gland.

His treatise *De Homine Liber* (1662) is in reality a treatise on physiology. It deals chiefly with the mode of action of the soul, but it gives a general view of all the functions of the body as they appeared to Descartes. He accepted Harvey's view of the passage of the blood from the arteries to the veins in the systemic circulation, but he did not accept the contraction or systole of the ventricles as the efficient factor in the propulsion of the blood. For him, the heart was expanded by its own innate heat. The great apostle of the application of physical laws to the elucidation and explanation of function both in man and animals was Borelli, whose mathematical genius led him to the study of physics, and from physics to physiology.

GIOVANNI ALPHONSO BORELLI.

1608-1679.

BORELLI, born of humble parentage at Naples in 1608, by his mathematical and physical studies, exerted a great influence on the progress of physiology, and founded a school, the iatro-mechanical, as distinguished from and opposed to the iatro-chemical. His learning as a mathematician secured him the Chair of Mathematics in the University of Messina, probably about 1640. He took a wide interest in phenomena outside his own specific studies. He wrote an account of the pestilence which raged in Sicily in 1647–48. Pisa and Padua were always in healthy rivalry. Borelli's fame led to his "call" by Ferdinand, Duke of Tuscany, to fill the Chair of Mathematics in Pisa. By an accident almost, as it were, the advent of Marcellus Malpighi in Pisa in 1656, brought Malpighi and Borelli together; and now Borelli took up the study of anatomical subjects.

In Pisa he laboured twelve years, and in 1668 returned to his old University of Messina, where he remained until 1674. Sicily at that time belonged to Spain. Borelli was suspected of some political conspiracy. In any case, he fled to Rome, where he came under the patronage of Queen Maria Christina, daughter of Gustavus Adolphus of Sweden. Adolphus died in 1644, but Christina, after a short term of queenship, preferred to reside in Rome. During all these years, Borelli had been labouring at his great work, *De Motu Animalium.* Christina promised to defray the expense of its publication, but did not. Misfortune overtook him, and in 1677, after this misfortune, he lived with and taught in the Society of the Scholæ Piæ of San Pantaleone until his death, in 1679. His great work was not published until after his death: the first volume in 1680, the second in 1681. It is somewhat remarkable how it escaped the strict censorship of the Church at that time.

The problems of motion in man and animals, resistance of air and water, the limbs as levers, the mechanism of voluntary and mixed movement, the movements of the heart and chest engaged his attention. He regarded respiration as due to contraction of the diaphragm and the intercostal muscles and the elasticity of the air. The air yielded to the blood in the lungs a *sal vitæ*. Some of the problems remained much as he left them, until E. H. Weber attacked them again in the middle of last century. He anticipated the experiments of Réaumur and others on the contractile force of the gizzard in birds.

Borelli studied not only the movements as brought about by muscles, or groups of muscles, but also the problem of how muscles change their form. In connection with the latter problem, we must remember that the microscope was now being used by anatomists. Malpighi was using it in Pisa. In 1664 Nicolas Stensen—Steno—published a little tract, *De Musculis Observationum Specimen,* which took the title of *Elementorum Myologiæ Specimen* in 1667. The work is illustrated by bold diagrams of the arrangement of fibres in various muscles. Stensen had a very fair knowledge of the general build of a muscle. He even noticed the difference in colour between what we now know as the red and pale skeletal muscles of the rabbit.

Borelli, like Stensen, recognised that the fleshy part, and not the tendinous part, was the real contractile part. In the original figure it is marked "caro."

The mechanical problems of the circulation, of course, arrested Borelli's attention. He figures the general arrangement of the muscular fibres of the heart, and endorses the view of Harvey, that the blood is propelled by the systole of the ventricles, as in the action of a winepress. Naturally, as a mathematician, he attempted to estimate the force, or mechanical value, of the systole of the ventricles.


H. Frölich sculps.


Caluaria auulsa de arbore pendet.
Duram matrem ostendit, per quã ita deerrant venæ sursum à iugularibus internis vtrinque delatæ, quemadmodum supra dictum est. Cuius medium ita finditur vt vides, & ligamentosum est admodum.

To do this he compares the volume of the heart muscle with that of the temporal and masseter muscles and the weight they can support. He makes acute observations on the flow of blood in the arteries. His observations in this regard bring one to the time of Stephen Hales, who was the first to measure accurately the blood-pressure in the arteries of a horse.

Harvey also applied a numerical method in connection with the amount of blood passing through the heart, and his calculation formed part of the evidence he adduces that led him to think that the blood might, "as it were, move in a circle." Here is the passage :—

"But what remains to be said upon the quantity and source of the blood which thus passes is of so novel and unheard of a character, that I not only fear injury to myself from the envy of a few, but I tremble lest I have mankind at large for my enemies, so much doth wont and custom, that become as another nature, and doctrine once sown and that hath struck deep root, and respect for antiquity influence all men. Still the die is cast, and my trust is in my love of truth, and the candour that inheres in cultivated minds. And sooth to say, when I surveyed my mass of evidence, whether derived from vivisections and my various reflections on them, or from the ventricles of the heart and the vessels that enter into and issue from them, the symmetry and size of these conduits—for nature, doing nothing in vain, would never have given them so large a relative size without a purpose—or from the arrangement and intimate structure of the valves in particular, and of the other parts of the heart in general, with many things besides, I frequently and seriously bethought me, and long revolved in my mind, what might be the quantity of blood which was transmitted, in how short a time its passage might be effected, and the like ; and not finding it possible that this could be supplied by the juices of the ingested aliment without the veins on the one hand becoming drained, and the arteries on the other getting ruptured through the excessive charge of blood, unless the blood should somehow find its way from the arteries into the veins, and so return to the right side of the heart ; I began to think whether there might not be a motion, *as it were in a circle.* Now this I afterwards found to be true ; and I finally saw that the blood, forced by the action of the left ventricle into the arteries, was distributed to the body at large, and its several parts, in the same manner as it is sent through the lungs, impelled by the right ventricle into the pulmonary artery, and that it then passed through the veins and along the *vena cava,* and so round to the left ventricle in the manner already indicated. Which motion we may be allowed to call circular, in the same way as Aristotle says that the air and the rain emulate the circular motion of the superior bodies ; for the moist earth, warmed by the sun, evaporates ; the vapours drawn upwards are condensed, and, descending in the form of rain, moisten the earth again ; and by this arrangement are generations of living things produced ; and in like manner too are tempests and meteors engendered by the circular motion, and by the approach and recession of the sun."

It is a singular fact that, notwithstanding the laws of optics were well known to the ancients, the invention of spectacles and the microscope came very late in the history of human progress. Magnifying glasses were in use in the sixteenth century, but with the invention of the compound microscope a new and potent instrument was added to the investigators' armamentarium. In this connection we shall recall the work of some early pioneers, Malpighi, Grew, Swammerdam, Leeuwenhoek, Redi, and others.

MARCELLUS MALPIGHI.

1628-1661.

MALPIGHI was born at Crevalcore, near Bologna, in 1628, the year in which Harvey published his *Exercitatio*. Entering the University of Bologna in 1645, he took his degree in Medicine in 1653. In 1656 he obtained a Professorship there, but in the same year Ferdinand II., Grand Duke of Tuscany, created for him a special Chair of Institutes of Medicine in Pisa, which he held for three years. Borelli, his senior by twenty years, was also in Pisa, and the two became warm friends, Malpighi profiting from the knowledge of the "new learning," and Borelli in turn acquiring a knowledge of anatomy.

Malpighi retured to Bologna, where he remained for a short time. In 1662 he was invited to occupy the Chair of Medicine in Messina, and he accepted the offer. After four years, *i.e.* in 1666, his fame was such that his old University of Bologna invited him to return. He was invited by Innocent XII. in 1691 to become his physician. He died in Rome 1624, æt. 67, and was buried in the Church of St. Gregory in Bologna.

It is not possible here to do justice to the work of Malpighi, for his discoveries are not only numerous and epoch-making, but range over both the animal and vegetable kingdom. It was in Sicily that his attention was first directed to the structure of plants. The microscope was already in use, and Malpighi used it with marvellous success. His immortal work on plants, *Anatome Plantarum*, published by the Royal Society, and that of Dr. Nathaniel Grew, also published by the Royal Society, laid the foundation of Vegetable Morphology. It is for this reason and others that I have placed the portraits of Malpighi and Dr. Grew on the same plate. Malpighi was the contemporary of Harvey, Borelli, Stensen—whom he met in Rome on his return from Messina,—Redi, Rudbeck, and Bartholin, a galaxy of discoverers.

To his friend Borelli in 1660 he had communicated his researches on the structure of the lungs, and in 1661 he addressed his *Observationes Anatomicæ de Pulmonibus* (Bonon. 1661), to him. We leave aside the story of their differences, of the uncertain temper of Borelli, and all that belongs to "personal equations." The use of the microscope opened up new paths and led to new ideas. Malpighi described how the air-tubes open into air vesicles in the lungs. This observation made possible a theory of respiration, but the great fact was not yet clear. He studied at first the lungs of a dog. One cannot help reflecting how Harvey with

M. MALPIGHI.

N. GREW.

masterly genius made use of his knowledge of comparative anatomy, to add a big corner-stone to the stately edifice he was building. Malpighi, like another whose histological researches are the outcome of the judicious choice of the appropriate object of study combined with the "seeing eye"—I mean L. Ranvier, Professor of General Anatomy in the Collège de France, Paris,—had recourse, to the lung of the frog. What does not humanity owe to that paragon of animals from a physiological point of view? Consider! The "missing link" of the capillaries was found in its lung by Malpighi. The first accurate descriptions of red blood corpuscles by Swammerdam, and later by Leeuwenhoek, were made on its blood. Is not the basis of the physiology of muscle established on experiments on its gastrocnemius? Did not Pflüger establish that oxydation does take place in the tissues and not in the blood by his famous experiments on a frog, with all the blood washed out of its vessels and replaced by normal saline solution? As to its heart, has it not been cut, ligatured, and stimulated with all forms of stimuli, electrical and chemical? The names of Descartes and Stannius—dear old Stannius in far-off Rostock, the writer of an incomparable treatise on comparative anatomy—are associated with the early study of its physiology. On it the brothers Weber established the first fundamental experiment on cardiac inhibition. On it also Gaskell solved the problem of the course of accelerator and inhibitory impulses. On its spinal cord Johannes Müller confirmed the doctrine of the functions of the anterior and posterior roots of a spinal nerve; and was it not on a piece of the sciatic nerve of a frog—two inches in length—that Helmholtz measured the velocity of a nerve impulse, a problem that a few years before his great master J. Müller declared to be impossible of solution? Joseph Lister made his early observations on its pigment cells, and his researches on its vaso-motor nerves, and Waller his researches on the papillæ of its tongue. Its tissues, the cornea, and other parts have been the grounds on which many a battle royal regarding inflammation has been conducted; and so on. All this is directly beside the mark, but it indicates the importance of selecting a suitable animal for experiment. Returning now to Malpighi's observations with the microscope. In 1665, when examining the omentum of a guinea-pig he saw little flat red bodies which he took to be fat. They were the red blood corpuscles; he, however, did not recognise them as such. That extraordinary observer, Jan Swammerdam, had seen and described the red blood corpuscles in the frog in 1658, *i.e.*, seven years before Malpighi. Swammerdam died in 1680, and his great work, *Biblia Naturæ*, was not published until 1738, by his countryman the indefatigable Boerhaave. It was when examining the lung of a frog that Malpighi saw a "certain great thing," "magnum certum opus oculis video"

(Epist. II., 328), viz., the circulation of the blood in the vessels we now call capillaries. He also ligatured the root of the lung, and, after the vessels were turgid with blood, dried the lung and saw the red network on the vesicles. This method is still one which should be shown to every student of medicine, even in these days. Malpighi had thus found the missing link that made Harvey's discovery complete. In 1668, Anton van Leeuwenhoek saw the capillaries in fishes, *e.g.*, eels, and gave a careful description of them.

The results of his researches on the tongue of the ox, *De Lingua*, he addressed to Borelli. He described the lingual papillæ and traced nerves to them, and regarded them as organs of taste. Led from this to the skin—for the papillæ of the skin were then unknown, although Fabricius was acquainted with the epidermis and dermis—he discovered the layer of the epidermis called the rete mucosum or rete Malpighi in his honour.

In 1666, the year he left Messina, he published *De Viscerum structura, exercitationes anatomicæ;* accedit *Dissertatio de Polypo cordis.* (Bonon.) He describes the liver, spleen, and kidney. He already knew the difference between conglomerate glands, *i.e.*, those with a duct, as taught by F. Sylvius, and conglobate or lymph glands. As to the liver, although it had been carefully described by Fr. Glisson, Malpighi showed that it consisted of lobules, or acini, and that it formed bile as the parotid forms saliva, and is a conglomerate gland like the pancreas. He also gave careful descriptions of the spleen, and considerably advanced our knowledge of the kidney. In 1662, a youth, L. Bellini by name, a pupil of Borelli's, described the straight tubes that still bear his name and open on the apex of a Malpighian pyramid. Malpighi saw the convoluted tubules, described the capsules that still bear his name, and how each contains a cluster of blood vessels—a glomerulus—and he was of opinion that they must play a great part in the secretion of urine. He gives no illustrations. Practically little advance was made in our knowledge of the structure of these organs until we come to the time of William Bowman and Carl Ludwig. He also published a great work on embryology, *De formatione Pulli in Ovo*, 1666, thus carrying on, and greatly extending, the work of Fabricius and Harvey. It was printed, like so many of Malpighi's other works, at the expense of the Royal Society. The indefatigable Oldenburg, secretary of the Royal Society, when once he got into correspondence with Malpighi, kept up a long correspondence with him, and it was in response to an inquiry by Oldenburg that Malpighi contributed his famous researches on the silkworm, including its development. The portrait is taken from his *Opera Posthuma*, 1697.

RENÉ DESCARTES.

1596-1650.

OVER three hundred years ago, there was born of a noble family at La Haye, near Tours in Touraine, one whose doctrines cannot be passed over in any work dealing with physiological learning. His early teachers were the Jesuits, then installed at La Flèche (1604-1612). In 1613 he went to Paris, and at twenty-one resolved to see the world in the guise of a volunteer—which appears to have been a usual custom with the French nobility in those days (1617). He was quartered at Breda, and also at Neuburg on the Danube. While still soldiering in 1619, he made what he calls a marvellous discovery—it was nothing less than the solution of geometrical problems by algebraical symbols. He was, indeed, the originator of analytical geometry. More travels through Europe—Ulm, Prague, La Rochelle, Italy, Silesia—still all the time studying "the great book of the world." After having spent many *Wanderjahre*, he returned to Paris (1625-28), where he made the acquaintance of the scientific men of the day, and also of M. de Balzac of immortal memory, with whom later he kept up an extensive correspondence.

The Netherlands had already worked out its independence, both political and religious ; Descartes was anxious to keep on good terms with the Catholic Church, and he was not quite sure as to the tender mercies of the "Most Christian" King. He had the fate of Galileo before his eyes. Holland he called "the refuge of the Catholics." Thus it came that, having made up his mind to retire from the distractions of society, he at the age of thirty-two sought a quiet retreat in Holland, where, after nine years spent in learning and thinking, he published in 1637 his famous *Discours de la Méthode*, &c.—*Discourse touching the Method of using reason rightly and of seeking Scientific Truth*, which marks not only an epoch in human thought, but also in French prose—"the best prose in modern Europe." In Amsterdam, he says,—

"I go to walk every day amid the Babel of a great thoroughfare with as much liberty and repose as you"—he is addressing Balzac—"could find in your garden alleys. What other place could you choose in all the world, where all the comforts of life, and all the curiosities which can be desired are so easy to find as here? What other country where you can enjoy such perfect liberty?"

He learned such anatomy as he was acquainted with in Amsterdam by visiting various slaughter-houses in the town. His *Optics*, *Meteors*, *The World (Le Monde)* in which he proposed to explain the *a priori* principles of all physics, appeared in 1632-33. His

original sketch of his *De Homine et de Fœtu* was sketched out in 1633-34, although the work itself appeared in 1662. Such experiments however as he made, in connection with physiology, were made to verify an hypothesis which he had already formed, a method, of course, exactly the reverse of Harvey, and of the new Physics. Everything but his "rational soul" could be explained by his hypothesis of matter endowed with extension and mobility.

In *De Homine Liber* (1662) and his *Formation of the Fœtus* he developed his celebrated theory of man as an automaton. We have already referred in general terms to Descartes' views. He accepted Harvey's view of the circulation of the blood, but erroneously ascribed its cause to the heat generated in the heart.

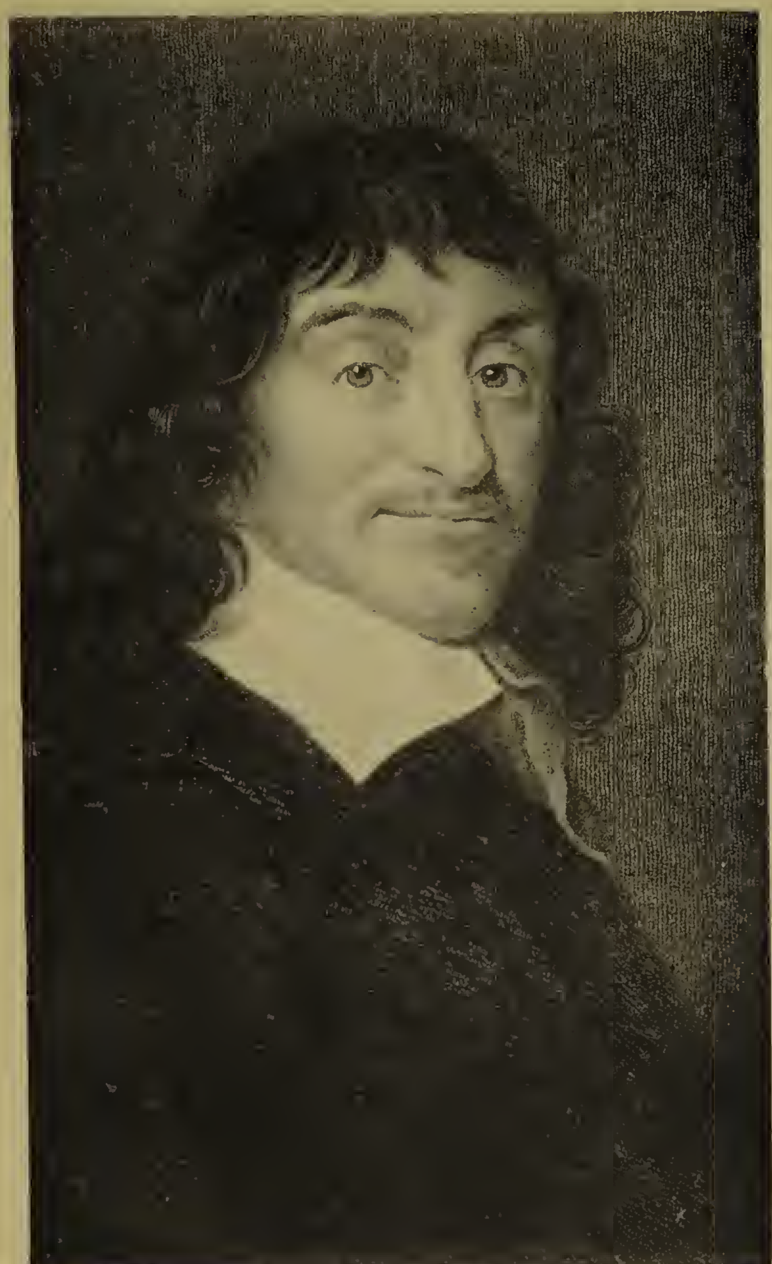
"This motion, which I have just explained, is as much the necessary result of the structure of the parts which one can see in the heart and of the heat which one may feel there with one's fingers, and of the nature of the blood, which may be experimentally ascertained, as is that of a clock of the force, the situation, and the figure, of its weight and of its wheels."

"As to the motion of the heart, he [Harvey] has said nothing not found in other books, and I do not approve of it; but as to the circulation of the blood, there he has his triumph and the honour of first discovering it, for which medicine owes him much." (Letter IX., 360.)

His view of man as an automaton is set forth in the following passages:—

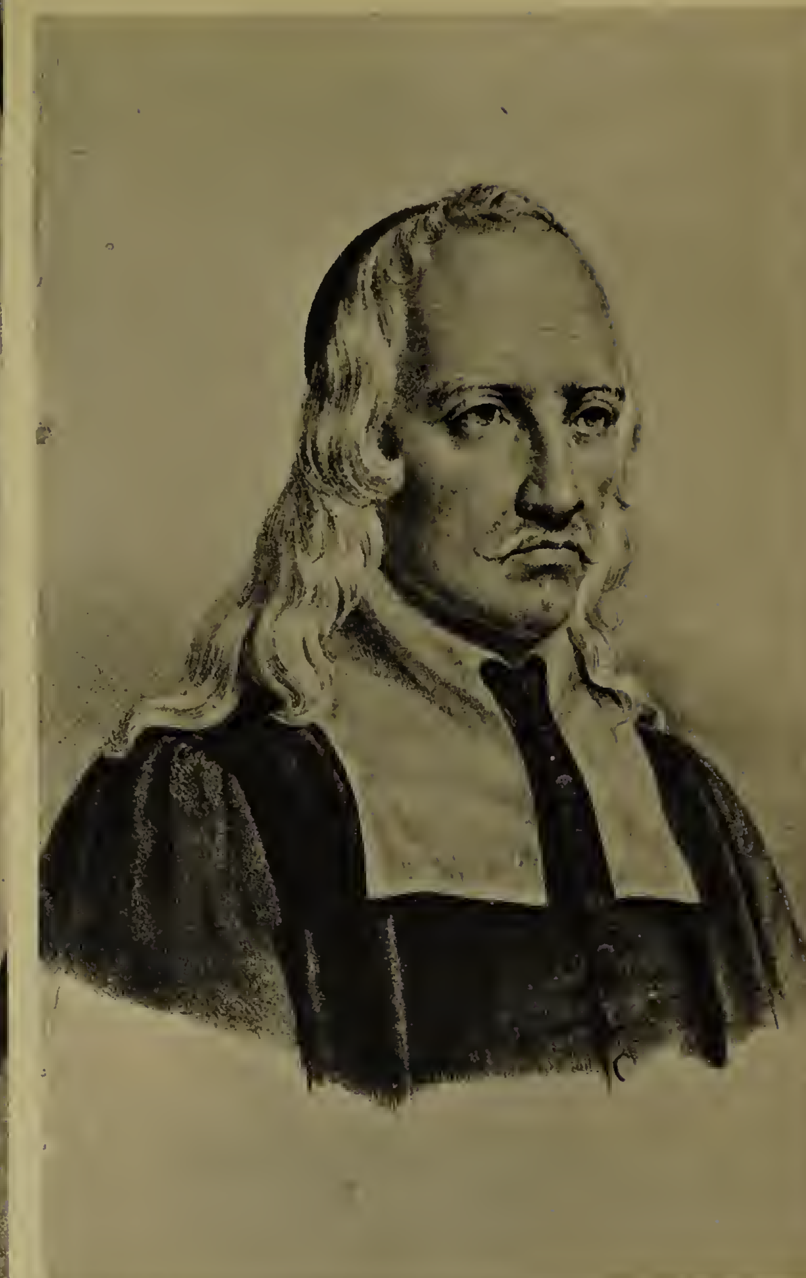
"The animal spirits resemble a very subtle fluid, or rather a very pure and lively flame, and are continually generated in the heart, and ascend to the brain as to a sort of reservoir. Hence they pass into the nerves and are distributed to the muscles, causing contraction, or relaxation, according to their quantity."

"In proportion as the animal spirits enter the cavities of the brain, they pass thence into the pores of its substance, and from these pores into the nerves; where according as they enter, or even only tend to enter, more or less, into this or that nerve, they have the power of changing the shape of the muscles into which the nerves are inserted, and by this means making all the limbs move. Thus, as you may have seen in the grottoes and fountains in our gardens, the force with which the water issues from its reservoir is sufficient to put into motion various machines, and even to make them play several instruments, or pronounce words, according to the varied disposition of the tubes which conduct the water. Indeed, the nerves of the machine may very well be compared with the tubes of these waterworks; its muscles and tendons with the other various engines and springs which seem to move these machines; its animal spirits to the water which impels them, of which the heart is the source or fountain; while the cavities of the brain are the central reservoir. Moreover, breathing and other like acts which are as natural and usual to the body or machine, and which depend on the flow of the spirits, are like the movements of a clock, or of a mill, which may be kept going by the ordinary flow of water. External objects which, by their mere presence, act upon the organs of sense; and which, by this means, determine the machine to move in many different ways, according as the parts of the brain of the machine are arranged, may be compared to the strangers who, entering into one of the grottoes of these waterworks, unconsciously themselves cause the movements which they witness. For they cannot enter without treading upon certain planks which are so disposed that, if they approach a bathing Diana, they cause her to hide among the reeds; and if they attempt to follow her, they



R. DESCARTES.

HON. R. BOYLE.



G. A. BORELLI.

see approaching towards them a Neptune, who threatens them with his trident; or if they pass in another direction they cause some sea-monster to dart out who vomits water into their faces; or like contrivances, according to the fancy of the engineers who made them. And lastly, when the rational soul—*l'âme raisonnable*—is lodged in this machine, it will have its principal seat in the brain, and will take the place of the engineer or 'fountaineer,' who ought to be in that part of the works or reservoir with which all the various tubes are connected, when he wishes to quicken or to slacken, or in any way to alter their movements." (*Traité de l'Homme*, Victor Cousin's ed. 1824, pp. 347–8.)

"The final summary is as follows (p. 427):—I desire you to consider all the functions which I have attributed to this machine [the body], as the digestion of food, the pulsation of the heart and of the arteries; the nutrition and the growth of the limbs; respiration, wakefulness, and sleep; the reception of light, sounds, odours, flavours, heat, and such-like qualities, in the organs of the external senses; the impression of the ideas of these in the organ of common sense and in the imagination; the retention, or the impression, of these ideas on the memory; the internal movements of the appetites and the passions; and lastly, the external movements of all the limbs, which follow so aptly, as well the action of the objects which are presented to the senses, as the impressions which meet in the memory, that they imitate as nearly as possible those of a real man; I desire, I say, that you should consider that these functions in this machine naturally proceed from the mere arrangement of its organs, neither more, nor less than do the movements of a clock, or other automaton, from that of its weights and wheels; so that so far as these are concerned, it is unnecessary to conceive in it any soul—whether vegetative or sensitive—or any other principle of motion, or of life, than its blood and its spirits agitated by the heat of the fire which burns continually in its heart, and which is in no wise essentially different in nature from all the fires which are met with in inanimate bodies" (p. 428).

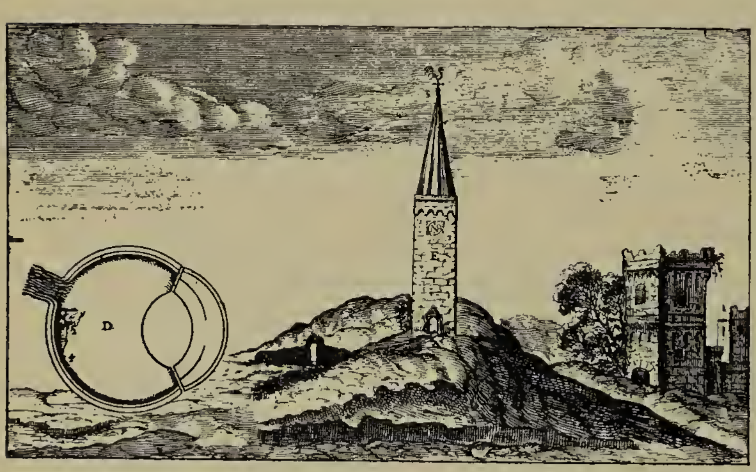
In his remarkable treatise *On the Passions of the Mind* (*Les passions de l'âme*) composed for his patroness and friend the Princess Elizabeth, niece of Charles I., in 1646, but not published until 1649, we come across one of the most fundamental experiments, which marks the early beginning of the history of what we now know as reflex action. In Article XIII., when dealing with the question as to how the brain excited by external objects affects the organs of sense, he says: "If some one aims a blow at the eyes, even though we know that he is a friend, and even if he does it in a joke, and without doing one any harm, we at once even against our will close our eyes. The action of heat on the skin similarly affects the skin nerves, which being set in motion pull upon the parts of the brain whence they take origin, and thus open up the orifices of certain pores on the internal surface of the brain. Through these pores the animal spirits flow from the ventricles and thus pass into the nerves and muscles, which carry out movements in the machine exactly like those to which we ourselves are incited when our senses are affected in the same way."

As to the working of the machine:—

"It is the more lively, strong, and subtle parts of the blood which reach the ventricles of the brain, and the arteries which carry them are those that pass in a nearly

direct line. . . . The part of the blood which reaches the brain serves not only to nourish it and maintain its substance, but its chief use is to produce there a very lively and pure flame which is called the *animal spirits.* The arteries which bring the blood from the heart, after dividing into an infinite number of small branches and having formed those delicate tissues which cover as with a carpet the floor of the ventricles of the brain, are gathered round a certain little gland which is placed about the middle of the substance of the brain just at the entrance to its ventricles, and in this situation these arteries have a large number of minute pores or holes through which the more subtle particles of the blood can flow into this gland, but which are so narrow as that they prevent the passage through them of grosser particles. [He gives a remarkable figure of the straight course of the arteries to the gland.] . . . The arteries do not end there, but, being gathered together there once again, they ascend straight upward and join the great vessel which is like a Euripus and which bathes the outer surface of the brain." (*L'Homme* p. 344.)

The *pineal gland* is thus the primary reservoir or bureau, the ventricles secondary reservoirs, of the animal spirits which flow from the brain along the tubular nerves, thus causing movements, the spirits themselves being generated from the innate heat of the heart. The pineal gland is also the seat of the rational soul. It is the "seat of imagination and of common sensation."



FORMATION OF INVERTED IMAGE OF AN EXTERNAL OBJECT IN THE RETINA.

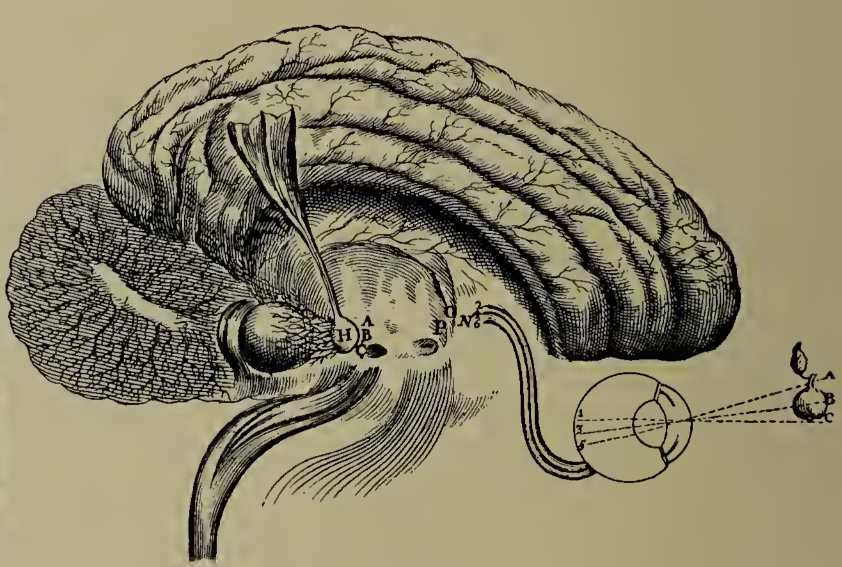


FIGURE SHOWING HOW THE IMPRESSION OF THE IMAGE OF AN EXTERNAL OBJECT ON THE RETINA REACHED THE PINEAL GLAND.

Passing over his many disputations and controversies, we come to the invitation in 1648 of that remarkable woman, Queen Christina, daughter of Gustavus Adolphus, "the pious and valiant King of Sweden," who was killed at Lutzen in 1632—we have already referred to her residence in Rome and her relations to Borelli—to him to reside in Stockholm that she might learn his philosophy direct from himself. This remarkable lady required his attendance at five a.m.—a very different hour from that usually selected by Descartes for active study, who usually lay in bed the better part of the forenoon meditating and writing. He died of pneumonia on February 11th, 1650, æt. 54.

FRANCIS GLISSON.

1597–1677 (æt. 80).

GLISSON was born at Rampisham, in Dorsetshire, just one year after Descartes, studied medicine and graduated at Cambridge, where he was Regius Professor of Physic for about forty years. M. Foster states that there is no evidence of his ever having delivered any courses of lectures (*Hist. of Phys.*, p. 287, 1901). He settled in London, and was Reader in Anatomy in the College of Physicians, in 1639, and became its president in 1667–9. He practised in Colchester during the troublous times of the civil wars. As already stated, he was one of the original group of scientific men who, about 1645–1662, laid the foundation of the Royal Society. In 1654, he published his treatise *De Hepate*, and in this connection we still have his name preserved in the "capsule of Glisson," although it was known both to Walæus and Pecquet. Glisson, however, was the first accurately to describe the capsule of the *vena portarum*, and the description he gave of its blood vessels was a distinct contribution to the subject, but his researches extended only to what can be observed by the unaided eye, and thus it was reserved for Malpighi, with a full knowledge of all the then recent discoveries in connection with glands, to recognise the liver as a conglomerate gland, which secreted bile, as the parotid secreted saliva.

Glisson was more than an anatomist or physician, he was also a philosopher and physiologist. He was clearly a man of decided views —he was an elder in a church in a small village in Essex—and had the courage of his opinions as regards the payment of his salary. Although there is no evidence that he gave lectures on physic in Cambridge, he attended from time to time "to keep acts," yet "in 1650 he petitioned the University for five years' arrears of salary, apparently the years 1643–4 to 1648–9, when, living at Colchester, he was wholly absent" (M. Foster, *Lect. on Phys.* p. 287, 1901). Sir Michael does not record the result. He remained in London during the plague in 1665, and the method he used to escape infection "was thrusting bits of sponge dipped in vinegar up his nostrils" (John Aikin, *Biogr. Mem. of Med.*, 1780).

Glisson records an important experiment on muscle physiology. In his *De Ventriculo et Intestinis*, his last work, published when he was already an old man, he gives an account of all that is known regarding the alimentary canal, and the irritability of its walls. The

matter of importance, however, is his description of what is perhaps the first plethysmograph experiment. The arm of a living person was placed in a cylindrical glass vessel with one end drawn out like a funnel and then the whole filled with water. When the person contracted his arm muscles the level of the water in the narrow tube fell; therefore, it was plain that during contraction a muscle was not inflated by any spirit or juice as supposed by Borelli. The variation in volume we now know was due to the effect of contraction on the blood-stream. We come again upon the same idea in Swammerdam's work. "The invention of this experiment is, however, by some attributed, upon the authority of the register of the Royal Society, to Dr. Goddard" (Aikin).

Glisson was also the founder of the doctrine of "irritability," a doctrine again taken up by Haller. Glisson used the word in its widest sense to indicate the power of parts to respond to various forms of stimuli to which reference is made elsewhere.

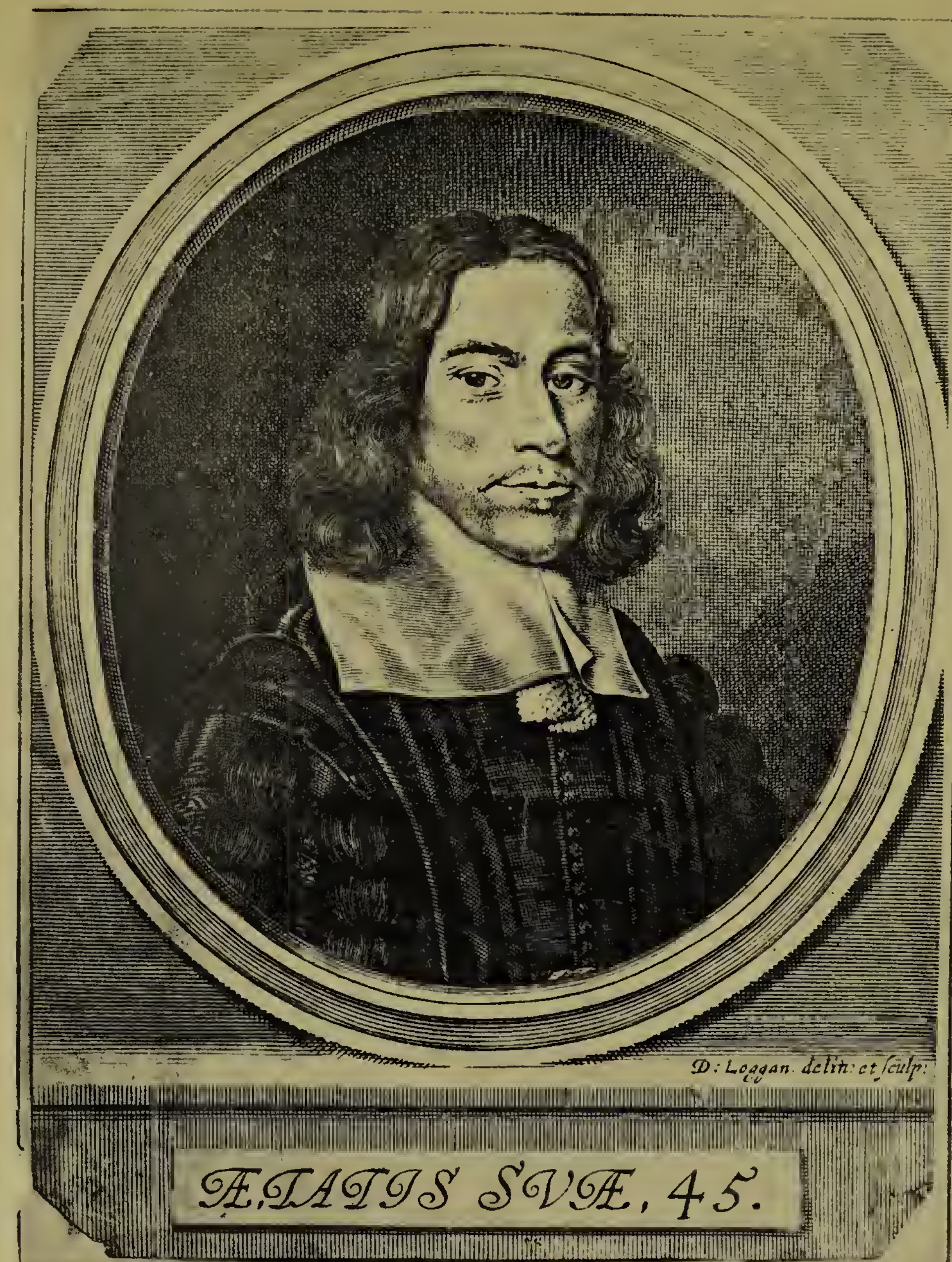
NICOLAUS STENSEN.

1638-1686 (æt. 48).

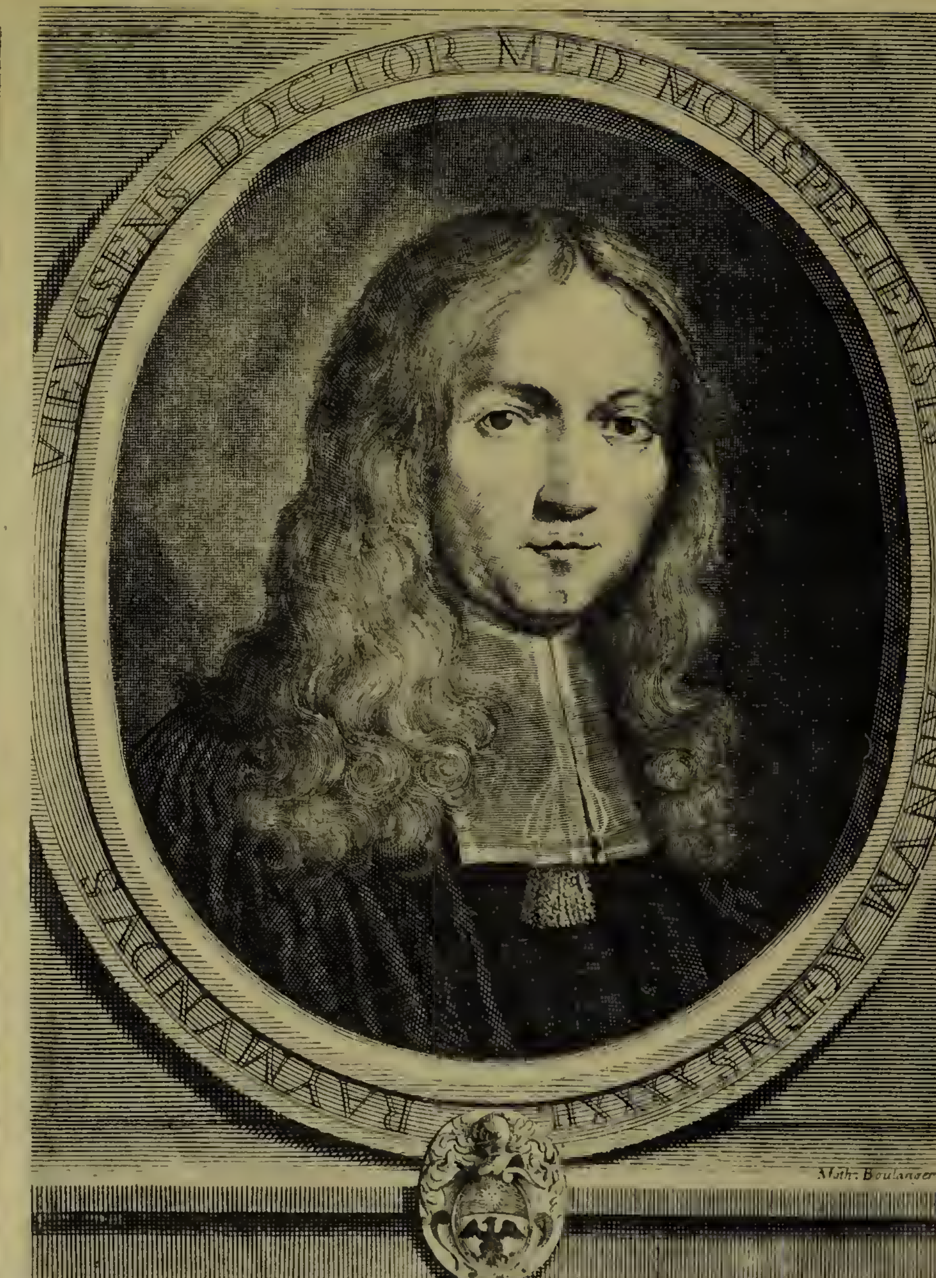
NIELS STENSEN is one of the most picturesque, pathetic, and withal brilliant of the apostles of physiology in the seventeenth century—Anatomist, Physiologist, Physician, Geologist, Priest, and Bishop. In his short span of less than fifty years he left an enduring mark of his genius, both on physiology and geology. He is perhaps better known by his Latin name of STENO. In 1656 he attended the University of his native town, where it was then the custom for a student to attach himself to some particular Professor, and Stensen chose Thomas Bartholinus. Simon Paulli, the precursor of Bartholin in the Chair of Anatomy, was also one of his teachers. It was customary for Danish students, after passing three years or so at their own University, to proceed to other Universities. Thus, we find Stensen in Amsterdam, three years later, in the house of Gerh. Blasius, a former pupil of T. Bartholinus.

Scarcely had Stensen, in 1661, begun to dissect, when he discovered the duct of the parotid gland, which bears his name, *ductus Stenonianus*. This discovery led to a dispute with Blasius, and Stensen went to Leyden, where, on the 6th and 9th of July, with Van Horne as president, he gave a brilliant *Disputation on his discovery of the glands with ducts*. Later, he investigated the glands connected with the eyeball—*De Glandulis Oculorum*. (Lugd. Batav.

FRANCIS GLISSON.



THOMAS WILLIS.



R. VIEUSSENS.

1661.) In a letter to his former teacher, Th. Bartholinus, on April 22nd, 1661, he tells us :—

"A year ago I was received in a friendly way by Blasius. At my request he allowed me to dissect, with my own hand, whatever I cared to buy. I was so fortunate that, on the first sheep's head which I bought and dissected alone in my own room, on April 7th, to discover a canal or duct that, so far as I know, no anatomist has described. As I reflected the skin, and was proceeding to dissect the brain, it occurred to me to dissect first of all the blood vessels that surround the mouth. In doing so, the point of my scalpel passed into a wide cavity, and I heard, on pushing on the steel, that it struck the teeth. Astonished at this discovery, I called to Blasius to ask his opinion. He took down Wharton's book to find the solution."

He also found the duct in the dog. At that time no one knew how saliva was formed. Some thought it came from the brain, others from the lymph, and some, again, from the papillæ of the tongue. In 1664, he published and dedicated to Friedrich III. his work on muscle and gland, *Observ. Anat. de Musc. et Glandul. Specimen.* (Hafn. 1664.) Haller, a century later, called this work an "aureus libellus," or "golden opuscule." The heart was recognised as muscular in its nature. Malpighi and Borelli knew that the heart was muscular, and the latter had calculated the force of its contraction. But Borelli's work was not published until 1680. Stensen speaks of the fibres of the heart, and compares the arrangement of some of them to the figure 8. He also busied himself with embryology. In this connection there is the excellent work of Fabricius.

Disappointed, perhaps, at not obtaining the Chair of Anatomy in Copenhagen—Matthias Jacobsen was appointed—he left Denmark, and once more wandered forth, this time to Paris, where he arrived about 1664. In Lutetia he made the acquaintance and lived in the house of the French Mecænas, Thévenot (1692). His acquaintance with Thévenot proved of great advantage to him, for it gave him an entry to scientific circles. In Paris he gave a lecture—*Discours sur l'Anatomie du Cerveau*—on the nervous system. J. B. Winslow, his countryman, Professor of Physic, Anatomy, and Surgery in Paris, has incorporated it in his *Anatomy* (1749).

The following are some extracts of this remarkable lecture from the English translation of Winslow's Works, by G. Douglas, M.D. :—

"The late M. Steno's Discourse on the Anatomy of the Brain was the sole original source, and general rule of my conduct in all that I have done in anatomy; and I have inserted in it the description of the head, believing that I should oblige my readers by reprinting a piece which was become very scarce, and which contains a great many excellent advices how to shun errors and discover truth, not only in relation to the structure and uses of the parts, but also in relation to the way of dissecting and of making anatomical figures.

"*A Dissertation on the Anatomy of the Brain, by M. Steno, read in the assembly held at M. Thévenot's House in the year* 1668. Instead of promising that I shall satisfy your curiosity in what relates to the Anatomy of the Brain, I begin by publicly and frankly owning that I know nothing of the matter. I wish I were the only person

under a necessity of talking in this matter, because I might in time become acquainted with what others know. . . . It is very certain that it is the principal organ of the soul, and the instrument by which it works very wonderful effects.

"If this substance is everywhere fibrous, as it appears in many places to be, you must own that these fibres are disposed in the most artful manner; since all the diversity of our sensations and motions depends upon them. We admire the contrivance of the fibres of every muscle, and ought still more to admire their disposition in the brain, where an infinite number of them, contained in a very small space, do each execute their particular offices without confusion or disorder. . . . As for my own part, it is my opinion that the true method of dissection would be to trace the nervous filaments through the substance of the brain, to see which way they pass, and where they end; but this method is accompanied with so many difficulties, that I know not whether we may hope ever to see it executed without a special manner of preparing. The substance of the brain is so soft, and the fibres so tender, that they can hardly be touched without breaking.

"The ancients were so far prepossessed about the ventricles as to take the anterior for the seat of common sense, the posterior for the seat of memory, that the judgment, which they said was lodged in the middle, might more easily reflect on the ideas which came from either ventricles. I would only ask those who are still of the same opinion, to give us the reason why we should believe them, for there is nothing satisfactory in all that has been hitherto said in favour of it; and as that fine arched cavity of the third ventricle where they placed the Throne of Judgment does not so much as exist, we may easily see what judgment is to be pronounced on the rest of this system.

"Willis is the author of a very singular hypothesis. He lodges common sense in the *corpora striata*, the imagination in the *corpus callosum*, and the memory in the cortical substance; but without being at pains to enter into details of his whole hypothesis, we need only make the following remarks upon it. . . .

"M. Descartes knew too well how imperfect an history we have of the human body, to attempt an exposition of its true structure; and accordingly, in his *Tractatus de Homine*, his design is only to explain a machine capable of performing all the functions done by man. Some of his friends have indeed expressed themselves on this subject differently from him; but it is evident from the beginning of that work, that he intended no more than what I have said; and in this sense, it may justly be said that M. Descartes has gone beyond all the other philosophers. He is the only person who has explained mechanically all the human actions, and especially those of the brain. The other philosophers describe to us the human body itself. M. Descartes speaks only of a machine, but in such a manner, as to convince us of the insufficiency of all that had been said before him, and to teach us a method of inquiring into the uses of the parts with the same evidence with which he demonstrates the parts of his machine called a man, which none had done before him.

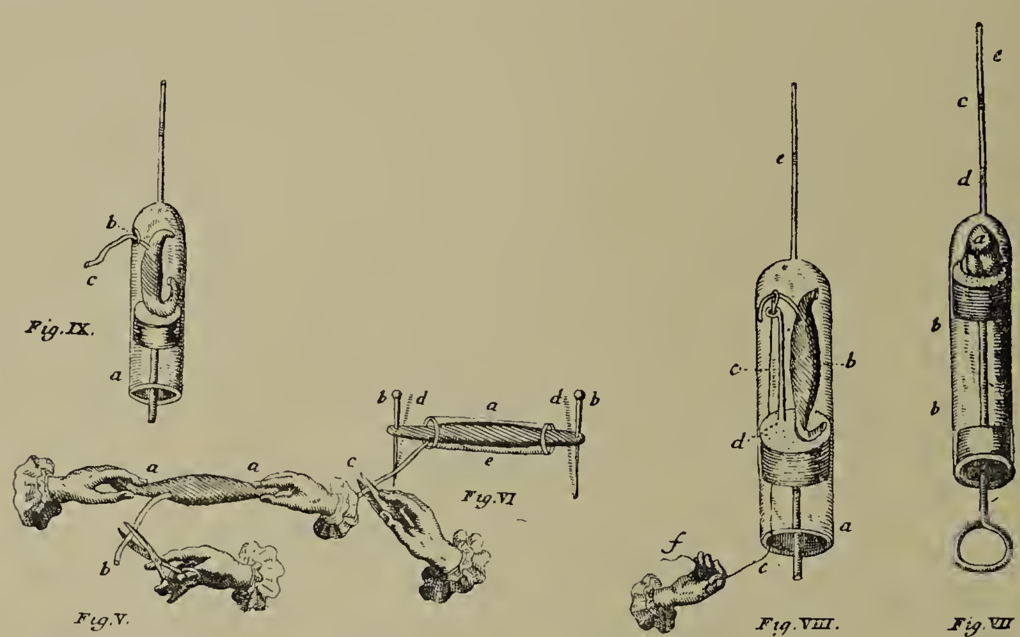
"We must not therefore condemn M. Descartes, though his system of the brain should not be found altogether agreeable to experience; his excellent genius, which shines nowhere more than in his *Tractatus de Homine*, casts a veil over the mistakes of his hypotheses, especially since even Vesalius himself, and other anatomists of the first rank, are not altogether free from such mistakes. And since we can forgive these great men their errors, who passed the greatest part of their lives in dissecting, why should not Descartes meet with the same indulgence, who has happily employed his time in other speculations? . . . I find myself obliged to point out some parts of his system, without relating the whole, in which they must see, if they have a mind to be instructed, the vast difference there is between Descartes's imaginary machine, and the real machine of the human body. The supposed connexion of the pineal gland with the brain by means of arteries is likewise groundless; for the whole basis of the gland adheres to the brain, or rather the substance of the gland is continuous with that of the brain, though the contrary be affirmed by Descartes."

"What necessity could there be to employ the words nates, testes, anus, vulva, and penis, which in their common signification have no relation at all to the parts expressed by them in the anatomy of the brain? And accordingly what one author calls nates, another calls testes, etc."

To Florence, then under the Medici and a centre of great intellectual activity, he went in 1666. The Grand Duke Ferdinand II. and his brother Prince Leopold greatly encouraged science, and, on the recommendation of Thévenot, the Grand Duke made Stensen his physician and gave him a pension as Court Physician. The results of his further study of muscles he sent to T. Bartholin. The work itself, *Elementorum Myologiæ Specimen* (1667), he dedicated to Ferdinand II. He regarded myology as a part of mathematics. In considering the contraction of a muscle, he opposes the view that the swelling and hardening are due to the influx of juices. He regarded muscles as parallelepipeds and treated of muscular action from a mechanical standpoint. His dissection of the head of a dog-fish (*Carcharias*) led him to geology, for the teeth of this animal led him to see that the *glossopetræ* were really fossil teeth. Stensen was brought up in the Lutheran faith. He joined the Catholic Church on 2nd November, 1667, and what is called his "conversion" excited great interest in the scientific world. Here is the story. As physician to the hospital Sta. Maria Nuova, he had occasion to go to the apothecary of the cloister, where he met Sister Maria Flava del Nero, who attended upon the apothecary. She soon learned that the great anatomist was what she regarded as a "heretic," and set to work to secure him for the Catholic Church. She succeeded; her offices being supplemented by those of Lavinia Felice.

In 1672 he was invited to return to Copenhagen to occupy the Chair of Anatomy, but he filled it with little success—his mind was filled with other ideas—and he quitted his native town in 1674 and returned to Florence. Theology and geology had for some years engrossed his attention. The results of his geological investigations on stratification of rock, fossils, &c., were published in his treatise *De Solido intra Solidum*, &c., in 1669. He is regarded as one of the founders of modern geology. Before he returned to Copenhagen he received the titular honour of Bishop of Titiopolis in Greece. He started northward with the idea of securing the allegiance of northern Europe to the Catholic faith. After quitting Copenhagen he laboured as a priest in Hanover and Schwerin, wearing himself out in constant labour for the principles of his newly-acquired faith. Worn out at the age of forty-eight, he died in 1686. His remains were interred in the Basilica San Lorenzo in Florence, and over them was erected, in 1883, by geologists of all nations, his bust, with a suitable dedication. (*Der Däne Niels Stensen*, by W. Plenkers, S.J., Freiburg in Breisgau, 1884.)

I CANNOT omit mention of that singularly gifted observer, and indefatigable naturalist, JAN SWAMMERDAM, who was born at Amsterdam in 1637. He travelled, like all the great Dutchmen of his time, to Italy and Paris. In Paris he stayed with Stensen in the house of Thévenot. He took his M.D. at Leyden in 1665. Unfortunately for science he was afflicted with an incurable melancholy, and died in 1680 æt. 48. As already stated, he was the first to see the red blood corpuscles of the frog, and his great work, *Biblia Naturæ,* was published in 1737–38, long after his death, by his compatriot Boerhaave. The following illustration, taken from the *Biblia Naturæ,* shows how Swammerdam studied some problems of muscular action. Most interesting of all are his experiments on



JAN SWAMMERDAM'S FIGURES FROM "BIBLIA NATURÆ," REGARDING CONTRACTION OF MUSCLE V., VI., VOLUME OF MUSCLE VIII., IX., AND OF HEART VII.

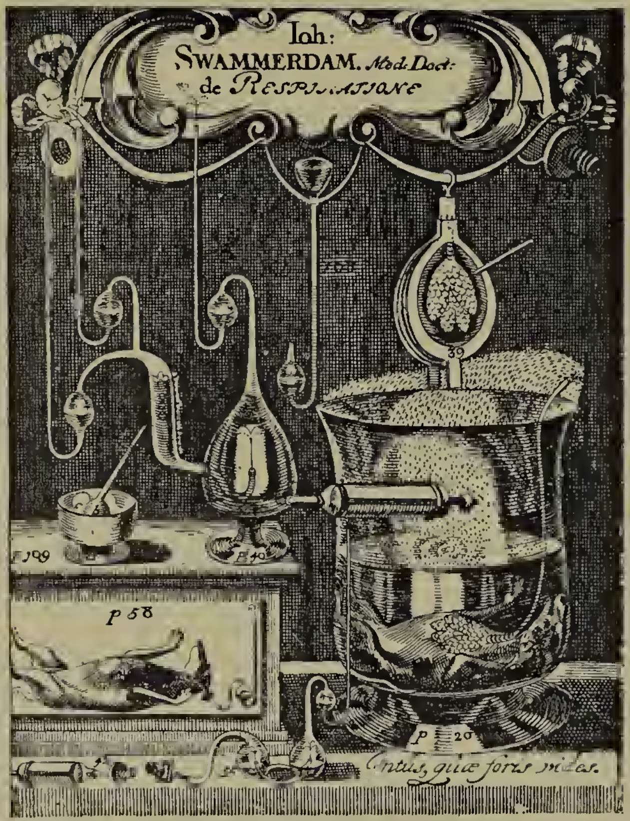
the volume of the heart. He placed the heart in a glass syringe with its nozzle drawn out to a fine tube. In the latter he placed a drop of water and watched it rise and fall with every diastole and systole of the heart. (Fig. VII.) He had anticipated by two centuries the plethysmographic researches of Blasius, Fick, Mosso, Marey, and others. In his experiments on muscle also, in Fig. V., when the muscle contracted the two hands—in Fig. VI. the two pins were drawn together—obviously he was at the very edge of a great discovery. It only wanted a recording surface, and the graphic method would have been invented. Figs. VIII. and IX. show his method of studying any change of volume of a muscle during contraction. Here a muscle is used instead of the arm in the experiment described by Glisson.

His *Tractatus de Respiratione* (1667) is of special interest. He imitated the movements of the chest wall by means of a pair of bellows. He placed an animal in water as shown in the illustration—the trachea connected with a tube with its orifice above the water—and observed the rise and fall of the water in the vessel with the move-

ments of respiration. He represents again the simplest form of a plethysmograph. Unfortunately there is no authentic portrait of Swammerdam, so I am informed by my old friend Professor Stokvis, of Amsterdam. In Rembrandt's *Leçon d'Anatomie* (N. Tulpius) the figure of Hartmans was considered as that of Swammerdam, but that is quite a mistake. On the two hundredth anniversary of his death—"Sterfdag"—there was fixed on the house where he lived in Amsterdam a tablet bearing the inscription—

JAN SWAMMERDAM
(1637–1680).
Zijn onderzoek der natuur blijft een
voorbeeld voor alle tijden.
17 *Feb.*, 1880.

A medal was struck in his honour on the ninetieth anniversary of the "Genootschap tot Bevordering van Naturgenees- en Heelkunde te



FRONTISPIECE FROM ONE OF THE EDITIONS OF SWAMMERDAM'S TRACT "DE RESPIRATIONE," SHOWING REPRODUCTIONS OF MOST OF THE FIGURES IN THE TEXT.

Amsterdam." On this occasion Professor B. J. Stokvis gave a brilliant address on the life-work of his great fellow-countryman.

SWAMMERDAM had as a contemporary FRANCESCO REDI (1626–1694), Professor of Medicine in Pisa, Physician, Poet, Naturalist, and Philosopher, whose works on insects and on the poison of the viper are classics. He was the first to use the term "Omne vivum ex ovo," and was one of the pioneers of the doctrine of Biogenesis. I well recollect the impression made on my mind long years ago by the remarks of Professor Joseph Lister in the operating theatre of the

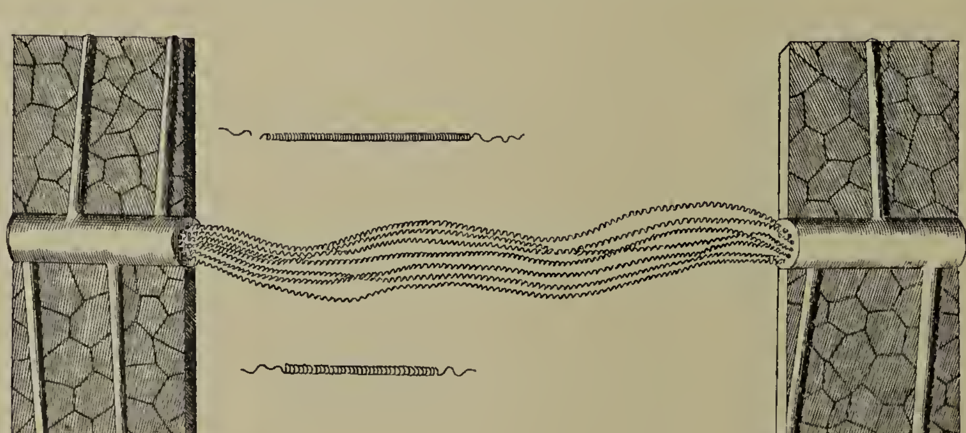
Edinburgh Royal Infirmary, when telling us the story of Redi and his researches on flies, and the simple method adopted by Redi to prevent putrefaction in meat.

Looking back on the old story, it is plain that the early naturalists held the key of the situation and did not know it—Redi, Spallanzani. Then came Schwann and Pasteur. Their biological life-work culminates in a simple issue—so simple, indeed, that all alike were working towards a common goal, a goal where stood fortunately one—trained in all the most modern methods of investigation, the pupil of Sharpey and Syme—who, from the fact of his physiological training, was enabled, as from a modern Pisgah, to see the riches of the land—not only the riches, but to see how all these converging lines of thought, experimentation, and whatnot, concentrated themselves in one practical issue—first as antiseptic, and now as aseptic surgery. There is no more picturesque story in the whole annals of surgery. What is, or ought to be, scientific surgery and medicine but applied physiology?

NEHEMIAH GREW.

1628(?)-1711.

THE Author—Physician and Botanist—of *The Anatomy of Plants, with an Idea of a philosophical history of Plants* (1682), was born at Coventry about 1628. His original paper was presented to the Royal Society at the same time as a similar work by Malpighi in 1671. His *Anatomy of Plants* is illustrated by magnificent plates, and was published by the Royal Society. It contains the idea of cells or "bladders." In honour of Malpighi—who, while in Messina, was led to the study of plant structure by seeing the vascular bundles hanging from a broken leaf of a chestnut—I have reproduced N. Grew's figure of what he calls the "Aer-vessels unrooved in a



THE AER-VESSELS, *i.e.*, VASCULAR BUNDLES, UNROOVED IN A VINE.

vine leaf." In dedicating his work to Charles II. he states that "there are *terræ incognitæ* in philosophy as well as in geography."

FREDERICK RUYSCH.

1638-1731.

THE Hague was his birthplace, and there he set up as an apothecary, going to Leyden to study under Sylvius and van Horne, where he graduated as M.D. in 1664. He was a lecturer on anatomy, taught midwifery and botany. He was, however, essentially an anatomist, famous for his anatomical injections—we still use the term *tunica Ruyschiana*—an art which it is said he learned from Swammerdam. His works abound in plates with objects fantastically grouped. In 1717 his great anatomical collection was sold to Czar Peter for 30,000 florins, but only part thereof, it is said, reached St. Petersburg, as the sailors drank the spirits. Another collection was sold to Sobieski, of Poland, who presented it to the University of Wittenberg, so famous in the story of Luther and the Reformation.

A. VAN LEEUWENHOEK.

1632–1723 (æt. 91).

BORN at Delft, Leeuwenhoek spent his early years in a linen draper's establishment; at the age of twenty-two he received a sinecure office in his native town. An indefatigable worker, most diligent and supremely conscientious, he applied his energy to the investigation of the minute structure of practically everything he could lay his hands on. He made his own lenses. R. de Graaf in 1673 sent his first communication to the Royal Society, to which he communicated paper after paper. He was the first to carefully describe the red-blood corpuscles; he confirmed the observation of Malpighi on the capillaries (1688); he described and figured the spermatozoa of the dog and other animals; he showed the difference in structure between the stems of monocotyledons and dicotyledons, the crystalline forms of various salts; he described infusoria in 1675, and rotifers, the bacteria as we now know them, or animalcules that he found in his own mouth, the stucture of teeth, crystalline lens, &c. His *Opera omnia seu Arcana naturæ* were published at Leyden in 1792, and an English translation by S. Hoole in 1798–1800. His observations were all made with the simple microscope. He made his own, and had several hundreds of them. Each consisted of a small biconvex lens, placed in a socket between two plates of brass, which were riveted together and pierced with a small hole opposite the lens. The object to be examined was fixed at a convenient distance and its focal distance adjusted by screws.

THOMAS WILLIS.

1621–1675.

THIS fashionable physician, whose name comes down to us in the "circle of Willis" and "accessory nerve of Willis," was born at Great Bedwyn in Wiltshire. At first he studied theology at Oxford and took his M.A. in 1642. Later he took to medicine. He was made Sedleian Professor of Natural Philosophy in Oxford in 1660 at the Restoration, and went to London in 1666, where he practised until his death. He gave accurate descriptions of the brain, but, perhaps, the chief merit in this regard belongs to Lower, rather than to Willis. His views about the physiology of the brain in particular were vague to a degree (Stensen's discourse, p. 32). There are some indications in his works that he had some glimmering of what are known now as reflex actions.

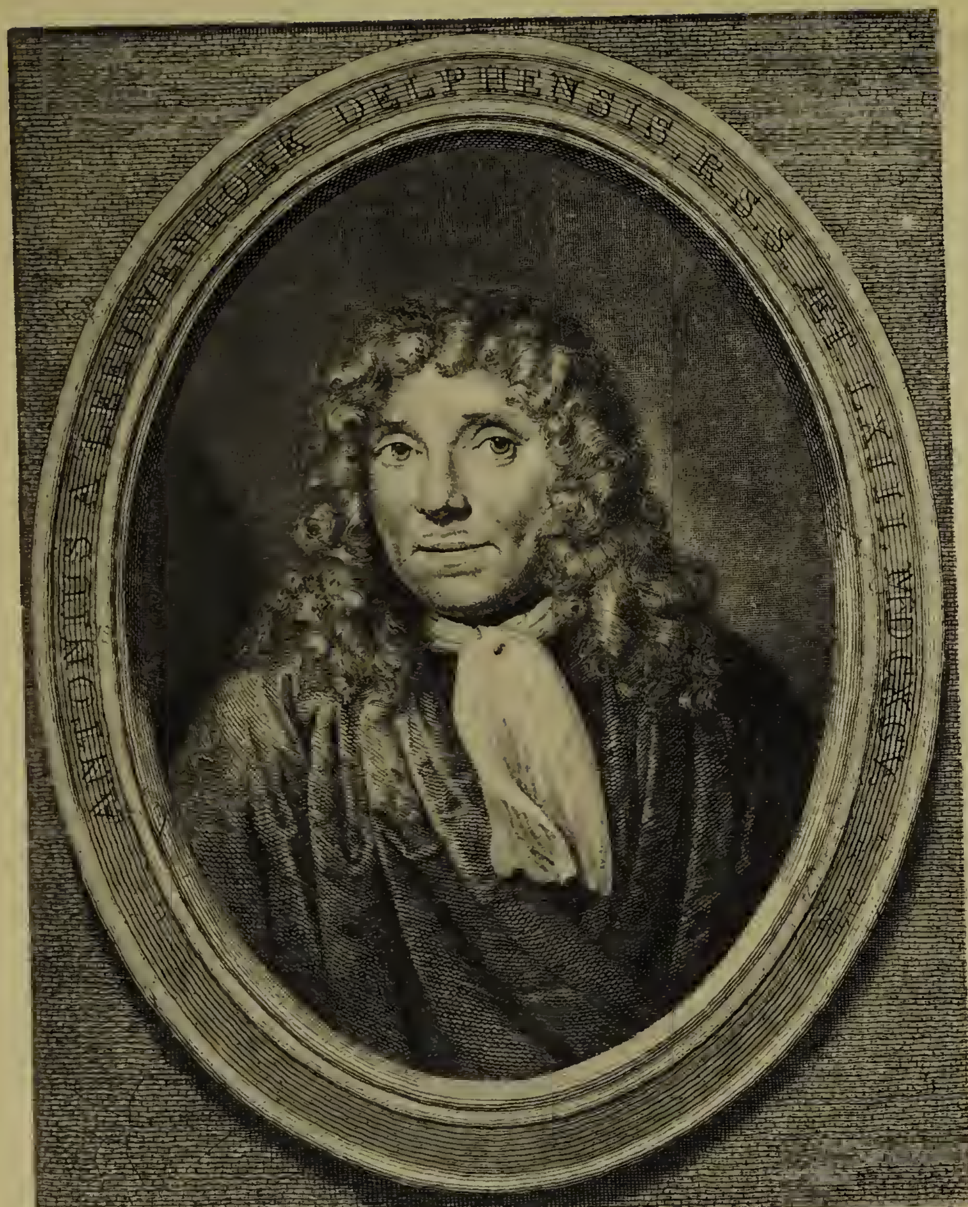
R. VIEUSSENS.

1641–1716.

MONTPELLIER has given many distinguished sons both to science and to letters. Raymond Vieussens was for a long time Professor of Anatomy, and the numerous autopsies which he conducted enabled him to contribute materially to the advancement of anatomy. We still speak of the "valve of Vieussens" and the "annulus of Vieussens." He was the first to describe the *centrum ovale*, and the pyramids and olives of the *medulla oblongata.* His *Neurologia Universalis*, with many excellent plates, was published in Lyons, 1685. In 1688 he published his *De natura . . . . . fermentationis*, in which he describes various forms of fermentation on the lines of Van Helmont and Sylvius. His chemical doctrines brought him into conflict with his colleague Chirac. He gave many fantastic names to different parts of the brain. Judging from the diatribe of Stensen on this subject, one would have thought that there were few of such names left for appropriation.

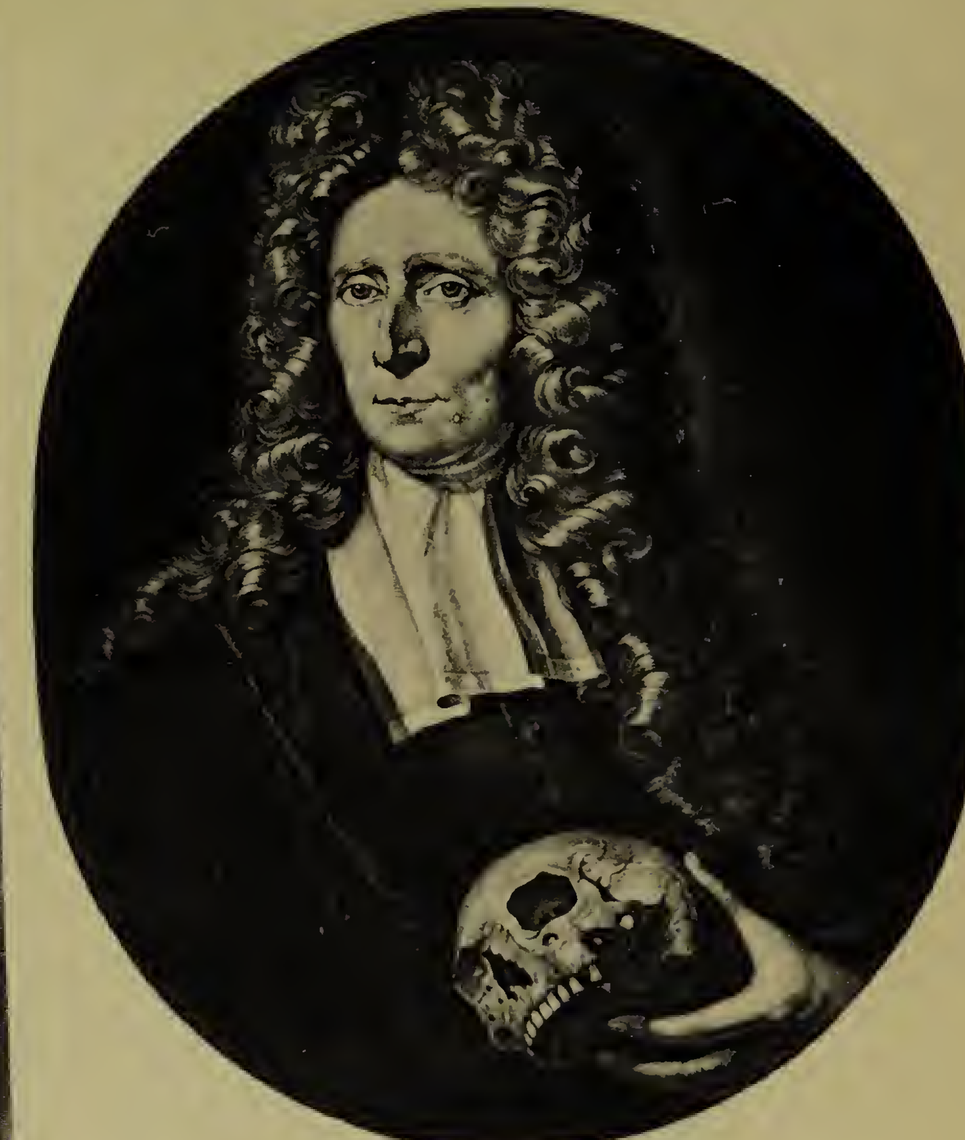
I have already referred to the fact that the influence of the discoveries of Torricelli and Galileo soon made itself felt in England, and how the Royal Society came to be founded. Conspicuous amongst its early members were Glisson, Boyle, Hooke, and Lower.

"The early part of the seventeenth century, when Descartes reached manhood, is one of the great epochs of the intellectual life of mankind. At that time physical science suddenly strode into the arena of public and familiar thought, and openly challenged, not only Philosophy and the Church, but that common ignorance which passes by the name of common sense. The assertion of the motion of the earth was a defiance to all these, and Physical Science threw down her glove by the hand of Galileo. . . . . But two hundred years have passed, and, however feeble or faulty her soldiers, Physical Science sits crowned as one of the legitimate rulers of the world of thought." (T. H. Huxley, *On Descartes*, 1872.)



A. VAN LEEUWENHOEK.

FRANCISCUS SYLVIUS.



FRED. RUYSCH.

The following is the account given in 1696 by Dr. Wallis, one of the founders of the Society :—

" Our business was (precluding matters of theology and state affairs) to discourse and consider of philosophical enquiries, and such as related thereunto :—as Physick, Anatomy, Geometry, Astronomy, Navigation, Staticks, Magneticks, Chymicks, Mechanicks, and Natural Experiments; with the state of these studies and their cultivation at home and abroad. We then discoursed of the circulation of the blood, the valves in the veins, the *venæ lacteæ*, the lymphatic vessels, the Copernican hypothesis, the nature of comets and new stars, the satellites of Jupiter, the oval shape (as it then appeared) of Saturn, the spots on the sun and its turning on its own axis, the inequalities and selenography of the moon, the several phases of Venus and Mercury, the improvement of telescopes and grinding of glasses for that purpose, the weight of air, the possibility or impossiblity of vacuities and nature's abhorrence thereof, the Torricellian experiment in quicksilver, the descent of heavy bodies and the degree of acceleration therein . . . . with other things appertaining to what hath been called the New Philosophy, which, from the times of Galileo at Florence, and Sir Francis Bacon (Lord Verulam) in England, hath been much cultivated in Italy, France, Germany, and other parts abroad as well as with us in England."

Hon. ROBERT BOYLE.

1626-1692.

ROBERT BOYLE was the seventh son and fourteenth child of the first Earl of Cork, and was born at Lismore, Waterford, January 25th, 1626. Endowed with ample means, he devoted himself to physical and chemical studies. He settled in Oxford in 1654, where he devoted much time to pneumatic chemistry, and to the study of the weight and pressure of the atmosphere and allied phenomena. With the air-pump of Otto von Guericke he made some of the most fundamental experiments on the physiology of respiration. At that time the " elater " or spring of the air attracted the attention of the physicists. It will suffice to quote one fundamental experiment in Boyle's own words.

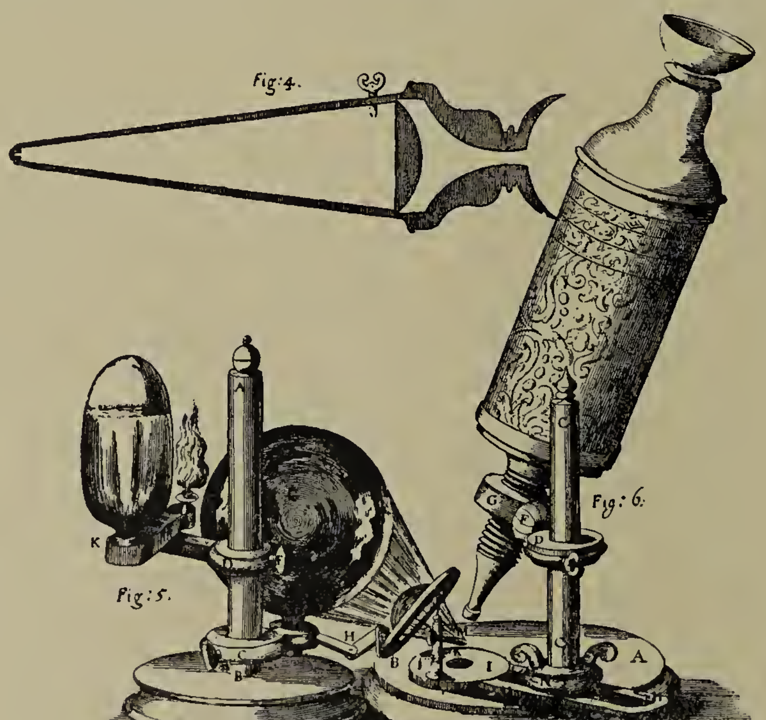
" *Birds and Mice in the Exhausted Receiver.*—To satisfy ourselves, in some measure, why respiration is so necessary to the animals, that nature hath furnish'd with lungs, we took a lark, one of whose wings had been broken by a shot; but, notwithstanding this hurt, the bird was very lively; and put her into the receiver, wherein she, several times, sprung up to a considerable height.

" The vessel being carefully closed, the pump was diligently ply'd, and the bird for a while appear'd lively enough; but, upon a greater exsuction of the air, she began manifestly to droop, and appear sick; and, very soon after, was taken with as violent, and irregular convulsions, as are observ'd in poultry, when their heads are wrung off, and died (tho' when these convulsions appear'd we let in air,) with her breast upward, her head downward, and her neck awry; and this within ten minutes, part of which time had been employ'd in cementing the cover to the receiver. Soon after we put a lively hen-sparrow, which was not at all hurt, into the receiver; and prosecuting the experiment, as with the former, she appear'd to be dead within seven minutes; one of which was employ'd in cementing on the cover: but, upon suddenly turning the key, the fresh air, flowing in, began slowly to revive her: so that, after some pantings, she open'd her eyes,

and regain'd her feet, and, in about a quarter of an hour after, attempted to escape at the top of the glass, which had been unstop'd to let in the air upon her: but the receiver being closed the second time, she died violently convuls'd, within five minutes from the first stroke of the pump.

"Then we put in a mouse, newly caught, and, whilst he was leaping up very high in the receiver, we fasten'd the cover to it; expecting, that an animal, used to live with very little fresh air, would endure the want of it better than the birds; but tho', for a while after the pump was set on work, he continued leaping up, as before; yet 'twas not long ere he began to appear sick, giddy, and to stagger; after which, he fell down as dead, but without such violent convulsions as the birds had: when, hastily letting in some fresh air upon him, he recover'd his senses, and his feet, but seem'd to continue weak and sick; at length, growing able to skip as formerly, the pump was ply'd again, for eight minutes; about the middle of which space, a very little air, by mischance, got in at the stop-cock; and, about two minutes after that, the mouse, several times, leap'd up lively; tho', in two minutes more, he fell down quite dead; yet with convulsions far milder than those wherewith the birds expired. This alacrity, so little before his death, and his not dying sooner than at the end of the eighth minute, seem'd owing to the air that pass'd into the receiver; for, the first time, the convulsions seiz'd him, in six minutes after the pump began to be work'd. These experiments seemed the more strange, because during a great part of those few minutes, the engine could but considerably rarify the air, and that too by degrees; and, at the end thereof, there remained in the receiver a large quantity; for, as we formerly said, we could not draw down water in a tube, within much less than a foot of the bottom. And, by the exsuction of the air, and interspersed vacuities, there was left in the receiver a space some hundreds of times exceeding the magnitude of the animal, to receive the fuliginous steams, from which, expiration discharges the lungs, and which, in the other cases, may be suspected, for want of room to stifle those animals that are closely pent up in too narrow receptacles." (*Collected Work of the Hon. R. Boyle*, by Peter Shaw, M.D., vol. II., p. 461, 1725.)

A SINGULARLY able man was ROBERT HOOKE (1635-1703), a born experimentalist and accurate observer, who made another advance in the physiology of respiration possible. Hooke was assistant to Boyle, and when the Royal Society was founded he was appointed Curator of Experiments. In his



ORIGINAL FIGURE OF HOOKE'S COMPOUND MICROSCOPE.

Micrographia, published by the Royal Society in 1667, he records his numerous "observations made on minute bodies of very varied kinds by magnifying glasses." The work is illustrated by fine plates.

The microscope he used was a compound microscope, and was about three inches in diameter, seven long, and provided with four draw tubes. It had three glasses—an object glass, a middle glass, and a deep eyepiece. Dr. Hooke also described a simple method of estimating the magnifying power of a compound microscope.

"Robert Hooke, the son of a clergyman, was born at Freshwater, in the Isle of Wight, on 18th July, 1635. He displayed from his earliest years a ready apprehension, a strong memory, and a surprising invention. He took his degree of M.A. at Oxford in 1660. While at the University he became conspicuous by his mechanical inventions; and the air pump which he contrived for Mr. Boyle gave him so much celebrity, that we find his name included in the first list of members, chosen by the President and Council of the Royal Society, after they had received their Charter from Charles II. Soon after he was appointed Curator to the Society, and his business was to contrive and exhibit experiments at the meetings of that illustrious body."

In 1677 he succeeded Mr. Oldenburg as secretary of the Society. It seems that "towards the end of his life his temper, which was always bad, became intolerable. In his person he was small and deformed, but he was exceedingly active." (Thomson's *History of the Royal Society,* p. 332, 1812.)

"*An account of an Experiment made by Mr. Hooke of preserving Animals alive by blowing through their Lungs with Bellows.*—October 24th, 1667. I did heretofore give this illustrious Society an account of an experiment I formerly tried of keeping a dog alive after his thorax was all displayed by the cutting away of the ribs and diaphragm, and after the pericardium of the heart was also taken off. But divers persons seeming to doubt of the certainty of the experiment (by reason that some trials made of this matter by some other persons failed of success), I caused at the last meeting the same experiment to be shown in the presence of this noble company, and that with the same success as it had been made by me at first; the dog being kept alive by the reciprocal blowing up of his lungs with bellows, and they suffered to subside, for the space of an hour or more after his thorax had been so displayed, and his *aspera arteria* cut off just below the epiglottis, and bound on upon the nose of the bellows.

"And because some eminent physicians had affirmed that the motion of the lungs was necessary to life, upon the account of the promoting of the circulation of the blood, and that it was conceived the animal would immediately be suffocated as soon as the lungs should cease to be moved, I did (the better to fortify my own hypothesis of this matter, and to be the better able to judge of several others) make the following additional experiment, viz. :—

"The dog having been kept alive (as I have now mentioned) for above an hour, in which time the trial had been often repeated, in suffering the dog to fall into convulsive motions by ceasing to blow the bellows, and permitting the lungs to subside and lie still, and of suddenly reviving him again by renewing the blast, and consequently the motion of the lungs; this I say having been done, and the judicious spectators fully satisfied of the reality of the former experiment, I caused another pair of bellows to be immediately joined to the first by a contrivance I had prepared, and pricking all the outer coat of the lungs with the point of a very sharp penknife, this second pair of bellows was moved very quick, whereby the first pair was always kept full and blowing into the lungs, by

L

which the lungs were also always kept very full and without any motion, there being a continued blast of air forced into the lungs by the first pair of bellows, supplying it as fast as it could find its way quite through the coat of the lungs, by the small holes pricked in it, as was said before. This being continued for a little while, the dog, as I expected, lay still, as before, his eyes being all the time very quick, and his heart beating very regularly. But upon ceasing this blast, and suffering the lungs to fall and lie still, the dog would immediately fall into dying convulsive fits, but be as soon revived again by the renewing the fulness of his lungs, with the constant blast of fresh air.

"Towards the latter end of this experiment a piece of the lungs was cut quite off, where 'twas observable that the blood did freely circulate, and pass through the lungs, not only when the lungs were kept thus constantly extended, but also when they were suffered to subside and lie still; which seem to be arguments, that as the bare motion of the lungs without fresh air contributes nothing to the life of the animal, he being found to survive as well when they were not moved as when they were; so it was not the subsiding or movelessness of the lungs that was the immediate cause of death, or the stopping the circulation of the blood through the lungs, but the want of a sufficient supply of fresh air."

It was thus evident that an animal could be kept alive when all respiratory movements of the chest wall had ceased, and, secondly, even when the lung was kept inflated with fresh air, life was maintained. Respiration, therefore, depended not on movements of the lungs, but on a supply of fresh air.

RICHARD LOWER.

1631-1691.

THE name of Lower—a Cornishman—is still preserved in anatomical literature by the name "tubercle of Lower." He did a large amount of work for Thomas Willis while the latter resided in Oxford. At the death of Willis, in 1675, he came to London. His *Tractatus de Corde, item de Motu et Colore Sanguinis* was published in 1669, and an edition of his *Bromographia*—I only know it in German—in 1715. The difference between the colour of venous and arterial blood was well known, the difference in colour being ascribed to a kind of combustion taking place in the heart. It will be noticed that the work of Lower deals not only with the heart, but with the motion and colour of the blood. Lower saw the greater brightness, *i.e.* redness, in the upper part of a blood clot or crassamentum, and attributed it to its proper cause, the action of the air (*De Corde*, c. iii., p. 178). He also saw that a black crassamentum becomes bright red when it is turned up and exposed to the air. Lower suspected that, as the blood passes through the lungs, the change in colour is effected. This he put to the test by using the experiment of Hooke,

just quoted, *i.e.* exposing the heart of a dog and keeping up artificial respiration. He saw that the blood in the pulmonary vein was scarlet before it reached the heart; also that if the inflation of the lungs by means of the bellows was stopped, the blood in these veins became dark and venous. He even "perfused," as we now call it, venous blood through the lungs, and saw that, as long as the lungs were kept inflated, it flowed out by the veins scarlet in colour, but if no fresh air was blown into the lungs, or if the lungs were kept distended with the same air, it flowed out still as venous blood. He therefore concluded that this change was effected in the capillaries of the lungs, and that the change is effected by the air. This view was further strengthened by the action of the air on the crassamentum of the blood outside the body. He thought the blood was not merely exposed to air, but that the blood took up some of the air. There was no question of the blood taking up only one constituent of the air, for the composition of the atmosphere had not yet been ascertained. These fundamental and important views of Lower were largely neglected, and we find even Haller opposed the views of Lower.

About 1660 he seems to have perfected his method of transfusion, and much stir was made about it in 1665. At this time diseases were thought to be due to morbid qualities of the blood. This method held out a hope to replacing bad blood by good. Lower and Dr. Edmund King transfused blood in the human subject in 1668. There is an account of the process in *Phil. Trans.* No. 12 and No. 20 (1666), giving a general notice of the operation of transfusion carried out before the Royal Society in London and at Oxford. In France the process was ultimately forbidden by law.

Lower made estimates of the pressure exerted by the blood, calculated the amount discharged at each beat of the heart, calculated the work done by the heart, the velocity of the blood-flow in the arteries, and in fact touched and investigated some of the most important problems in hæmadynamics—a worthy successor of Borelli, and precursor of Hales, Poiseuille, and Ludwig. He was a worthy follower of Harvey, and followed his method—accurate observation and experimentation. There is one interesting experiment described by Lower and shown to the Royal Society on Oct. 17th, 1667—"making a dog draw his breath exactly like a wind-broken horse." He divided the phrenic nerves as they pass through the thorax. In this paper he gives an admirable exposition of the mechanics of the respiratory movements. Lower appears to me to stand out as one of the most clear-headed and logical experimenters of his day.

JOHN MAYOW.

1643-1679.

TRACING the evolution of the story we come next to John Mayow, who was born in London in 1643, where he died in 1679 "in the joyous neighbourhood of Covent Garden" at thirty-six, having accomplished much during the all too brief span of his existence. He took his degree in law, not in medicine, at Oxford. His famous work is *Tractatus de salė nitro-, et spiritu nitro-aereo, de respiratione, respiratione fœtus in utero et ovo, de motu musculari, et spiritibus animalibus, de rhachitide.* (Oxon. 1668.)

He knew that the heart was muscular and that the blood was forced out during systole, for "if the heart of an animal just killed be filled with water, you excite a movement like that which takes place in systole, the contents of the ventricle are forthwith ejected."

The mechanism of the entrance of air to the lungs he quite understands. Malpighi had already shown the structure of the lung. Mayow gives a figure of a bladder placed in a pair of bellows, with the mouth of the bladder communicating with the nozzle of the bellows. When the bellows are expanded, air rushes in, and, when compressed, air is forced out. He figures the intercostal muscles, and ascribes the increase in capacity of the chest during inspiration to the raising of the ribs and the descent of the diaphragm. Expiration is a passive act.

It is the chemical aspect of the question with which the name of Mayow is linked, for he showed that it was not merely a portion of the air which is necessary for combustion and for respiration, but a particular part—or constituent—of the air. He called it *sal nitro-aereum* or *spiritus nitro-aereus* or *igneo-aereus.* It was, in fact, the gas we now call oxygen, which as such was not discovered till more than a hundred years afterwards.

He refers to Boyle's experiments, which show that something in the air is necessary for the burning of every flame. The air for him was a compound body. The nitro-aereal spirit gave the air its power of supporting flame, and it was this that the blood in its passage through the lungs abstracted from the air. Like Boyle, he knew that, after breathing in a closed space, the volume of air was diminished, but Mayow appears to have been the first to estimate the amount. He puts it at $\frac{1}{14}$. Hales later on put it $\frac{1}{13}$ to $\frac{1}{30}$. Lavoisier in 1777 gave the amount as $\frac{1}{60}$. The older observers, still under the sway of the physical investigations on the elater or spring of the air, explained this diminution of volume by saying that the air has lost part of its elasticity or its spring. A candle burned in a closed vessel over

J. MAYOW.

R. DE GRAAF.

water, or an animal breathing under the same conditions, equally cause a diminution in the volume of the air—more, indeed, in amount when an animal is thus suffocated than when the candle goes out.

It may thus be taken that Mayow grasped the first factor of the process of external respiration, viz., that something is taken from the air by the blood. We have to wait a little longer before the knowledge of the second factor is fully discovered, viz., that the blood gives off something to the air in the lungs. Even Hales expresses the view that the expired air contains aqueous vapour and certain noxious effluvia, and has its spring diminished, a view endorsed by Haller.

"If a small animal and a lighted candle be placed in a closed flask, so that no air can enter, in a short time the candle will go out, nor will the animal long survive. . . . . The animal is not suffocated by the smoke of the candle. . . . The reason why the animal can live some time after the candle has gone out seems to be that the flame needs a continuous rapid and full supply of nitro-aereal particles. . . . . For animals, a less aereal spirit is sufficient. . . . The movements of the lungs help not a little towards sucking in aereal particles which may remain in said flask and towards transferring them to the blood of the animal." (Mayow.)

The hypothesis of Mayow as to the constitution of the atmosphere seems at first to have attracted considerable attention, but it was shortly afterwards abandoned or forgotten. Two quotations will suffice :—

"The total neglect into which the experiments of Mayow had fallen, during the greater part of the last century, must be regarded as a very singular occurrence in the history of science. . . . Mayow was a man of extraordinary genius, and one who, on many points, far outstripped the science of his age. . . . He saw the analogy of respiration to combustion, as well as the connection which subsists between these processes and one of the constituents of the atmosphere." (John Bostock, *Physiology*, 3rd ed. 1836.)

"When we look at his portrait we see a face delicate in outline, yet with a firm mouth, the visage of a man who had spent his as yet short days in the quiet but earnest and unresting pursuit of truth amid the calm of academic retirement. . . . Had his body been as strong as his mind was acute, had he lived to that ripe old age which was reached by many another leader in science, how different had been the story of chemical physiology ! " "But it was not to be. . . The world had to wait for more than a hundred years, till Mayow's thought rose again as it were from the grave in a new dress, and with a new name ; and that which in the first year of the latter half of the seventeenth century, as igneo-aereal particles, shone out in a flash and then died away again into darkness, in the last years of the eighteenth century, as oxygen, lit a light which has burned, and which has lighted the world with increasing steadiness, up to the present day." (M. Foster, *Lectures on the History of Physiology*, 1901.)

Of Chemical learning, in the real sense of the word, there was none until after the time when Harvey taught. Towards the end of the fifteenth century there lived in Erfurt a Benedictine monk, one BASIL VALENTINE, and an alchemist withal, who introduced the idea of an *archæus* or rather a variety of *archæi* as the dominant directive

factors in the universe. Early in the sixteenth century (1505) one who indirectly exerted a great influence on science, and left his mark on the progress of human thought, took his degree of Doctor of Philosophy, to wit, Martin Luther. The psychologist may find much to interest him, the politician may find something to explain, in the stay of Luther in the old Castle of the Wartburg, where ink rather than blood—as in Holyrood—serves to mark an episode of world-wide interest. Impulses, therefore, of far-reaching import proceeded from Erfurt which are still exerting their influence on physiology and on human progress. In the first half of the sixteenth century, we come across one picturesque and erratic figure, one who in his time played many parts and who took up this idea of an *archæus*, to wit, PARACELSUS (b. Einsiedel, 1493) —"Monarch of all Physicians," "King of Quacks." With aliases galore, he flitted hither and thither, and at last died in the Hospital of St. Sebastian, Salzburg, in 1541—about the time Vesalius was finishing his great *Fabrica*—æt. 48—he who "had compounded the tincture of life." The story of chemical physiology therefore begins with the alchemists, and a curious erratic story it is, which in part only can be told here. Necessarily it is linked with the progress of discovery in other departments. This old *archæus* takes one back to a memorable Sunday evening in Edinburgh in 1868, when THOS. H. HUXLEY delivered his famous address "on the physical basis of life." Some who listened to that address may recollect the storm it evoked. Let the dead bury their dead. Here is Huxley's view of this *archæus*, and right catholic it is :—

> "I ask you what is the difference between the conception of life as the product of a certain disposition of material molecules, and the old notion of an *archæus* governing and directing blind matter within each living body, except this—that here, as elsewhere, matter and law have devoured spirit and spontaneity? And, as surely as every future grows out of past and present, so will the physiology of the future gradually extend the realm of matter and law, until it is co-extensive with knowledge, with feeling, and with action."

One of the quaint books not unfrequently to be found on second-hand bookstalls is the *Medicina Statica*, being the Aphorisms of SANCTORIUS (1561–1636) translated by John Quincy, M.D., to which is added JAMES KEIL'S *Medicina Statica Britannica*. The motto explains the whole : *Pondere, Mensurâ et Numero Deus omnia fecit*, MDCCXX. His *Medical Statics*, published at Venice in 1614, deals with the following subjects, and under each section are many aphorisms—insensible perspiration ; air and water ; meats and drink ; sleep and watching ; exercise and rest ; venery ; affections of the mind. JAMES KEIL of Northampton gives another series of aphorisms. Both works afford much amusing reading. Keil was a Scotsman (1673–1719), who lectured at Oxford and Cambridge, published a work on anatomy, and wrote on animal secretion, the

quantity of blood in the body, and muscular motion (1708), and also "concerning the force of the heart in driving the blood through the body."

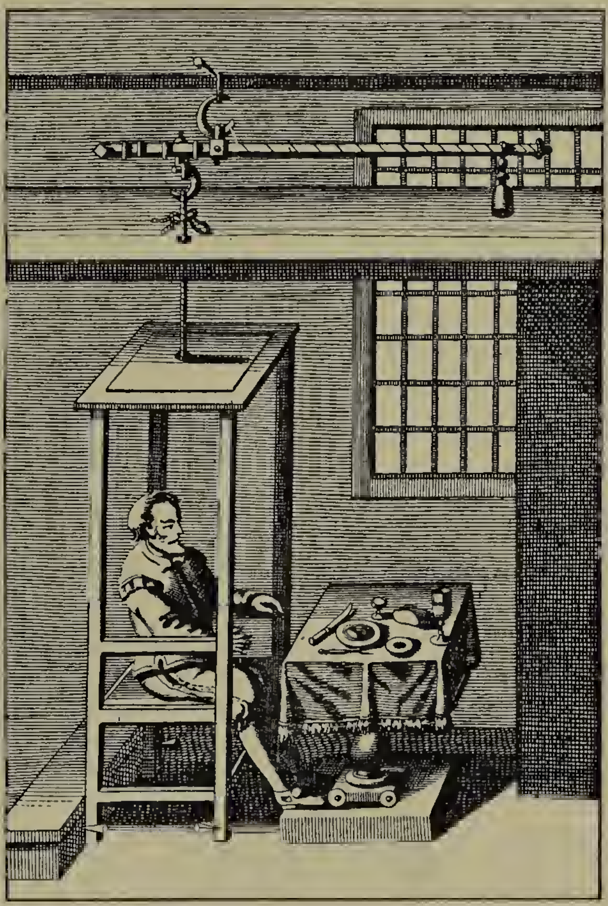
Here is a picture of Sanctorius and his method of weighing himself. The point in the whole affair is that long before the balance came to assume its true importance in matters chemical, Sanctorius had, by its use, found a means of determining the loss of weight of his own body under certain conditions by what is known as "insensible perspiration." It is obvious that the word perspiration is taken broadly. Two quotations will suffice.

APH. VI.

"If eight pounds of meat and drink are taken in one day, the quantity that usually goes off by insensible perspiration in that time is five pounds."

APH. XVII.

"A person may certainly conclude himself in a state of health, if upon ascending a precipice he finds himself more lightsome than before."



COPY OF THE ORIGINAL FIGURE IN THE "MEDICINA STATICA" OF SANCTORIUS.

Santorio—the Italian form of the name—the celebrated precursor of the iatro-mechanical school, was born at Capo d'Istria (1561), and studied at Padua, where he became Professor of Medicine (1611–1624). According to Nelli, Sanctorius invented and described a thermometer in 1612. (*Biog. Lexikon.*)

JEAN B. VAN HELMONT.

1577-1644.

THERE was born at Brussels, in 1577, one who exercised a great influence on the rise of chemical doctrine viz., Jean Baptiste van Helmont, who, after trying various studies, was attracted to medicine and graduated as M.D. in 1599. He had by marriage ample pecuniary resources ; and lived at Vilvorde, where he died in 1644. He introduced two new terms, "gas" and "blas." The latter perhaps corresponded to the *archæus* of Paracelsus. The term "gas" he applied to something which is like air, but is not the air of the atmosphere. He discovered it as a product of fermentations—*gas sylvestre.* He obtained it when charcoal was burned, a kind of spirit—a "geist." Geist, ghost, and gas are the same words. He saw that changes took place in the juice of the grape, and he assumed that this was brought about by a ferment, causing ebullition. Imbued with this idea of fermentation, he regarded all the processes in the economy, not only digestion in the intestinal tract, but all other changes of nutrition, as due to this process. His researches gave an impulse to the study of the chemical aspect of certain problems in physiology. The scene is now shifted to Holland.

FRANCISCUS SYLVIUS.

1614–1672.

SYLVIUS DE LA BOE, a Frenchman by descent and a Dutchman by adoption, was the great leader of the chemical sect. He graduated in medicine at Basel in 1637, and practised at Amsterdam, where he became familiar with the views of Descartes and Van Helmont. In 1658 he was appointed Professor of Medicine at Leyden, where he exerted a powerful influence on some of his celebrated pupils. He is said to have been the first to introduce the plan of giving lectures on his own individual cases in the hospital, a practice followed later with great success by Boerhaave. Moreover he seems to have been the first to found a University chemical *laboratorium.* His bias was towards chemical speculation and investigation. He adopted Harvey's view of the circulation of the blood. The "aqueduct of Sylvius" is named after him. He distinguished between conglomerate and conglobate glands.

Amongst his pupils were N. Stensen, of whom we have already spoken, and Regner de Graaf, or, as Stokvis calls him, Reinier de

Graaf. Sylvius regarded the processes in the human body as chemical, and of the nature of those that occur outside the body in chemical experiments. The process was of the nature of a fermentation, but this word was not used in the same sense as applied by Van Helmont. In fact this word " fermentation " had very varied meanings, according to the author who used it. R. Vieussens, as we have already noted, wrote a long dissertation on this subject. Sylvius was the founder of the iatro-chemical school, as opposed to the iatro-mechanical. He at least directed attention to the importance of chemical processes in the explanation of the phenomena of living beings.

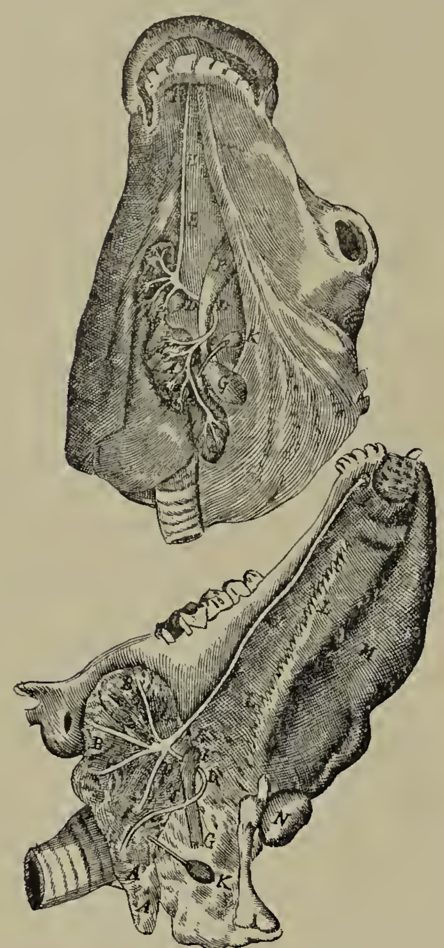
The fact that some glands possessed ducts and poured their juices into the intestinal canal arrested his attention, and accordingly one of his pupils conducted an investigation on the pancreas in 1664. The pancreatic duct, which still bears his name, was discovered by Wirsung in 1642, the duct of the sub-maxillary gland by Thomas Wharton in 1655–6, and that of the parotid gland by Stensen in 1661. Of the last we have already recorded the story. JOHN GEORGE WIRSUNG was Professor of Anatomy in Padua, and was therefore a remote successor of Vesalius and Fabricius. According to Cl. Bernard, he sent a copy of a copper-plate engraving of the duct to Riolan in 1643. He was assassinated on the 22nd August, 1643. Whereon Cl. Bernard remarks, in his famous lecture *Pancreas, Historique,* 23rd May, 1855 : "Nous constatons de nouveau ici que les découvertes anatomiques et physiologiques suscitent aujourd'hui moins de passions." There is a magnificent figure of this duct in De Graaf's work copied from that of Sylvius (1695), showing with a softness and delicacy a triumph of the engraver's art. It also shows justly how the smaller secretory ducts join the main duct nearly at a right angle.

THOMAS WHARTON.

1614-1673.

THE publication in 1656 of the *Adenographia* of Wharton, a Yorkshireman, marks an important epoch in anatomical discovery. It deals not only with glands without ducts, *e.g.* thymus, but, also with his own discovery of the duct of the sub-maxillary gland. He gives careful descriptions of all these glands, their nerves, blood-vessels, &c. The results were originally given in his lectures at the College of Physicians in 1652. I have reproduced his two figures of the sub-maxillary gland of the ox, as he was the first to discover the duct of a salivary gland. He recognised that it conducted saliva,

but, as regards the formation of saliva, he had recourse to fantastic views of the action of the *succus nerveus.* He failed to grasp the significance of his important discovery. His name is also associated with "Wharton's jelly" of the umbilical cord.



ORIGINAL FIGURES OF WHARTON'S DUCT OF THE SUB-MAXILLARY GLAND OF A CALF.

STENO'S ORIGINAL FIGURE OF THE PAROTID DUCT AND LABIAL GLANDS OF THE MOUTH OF A CALF.

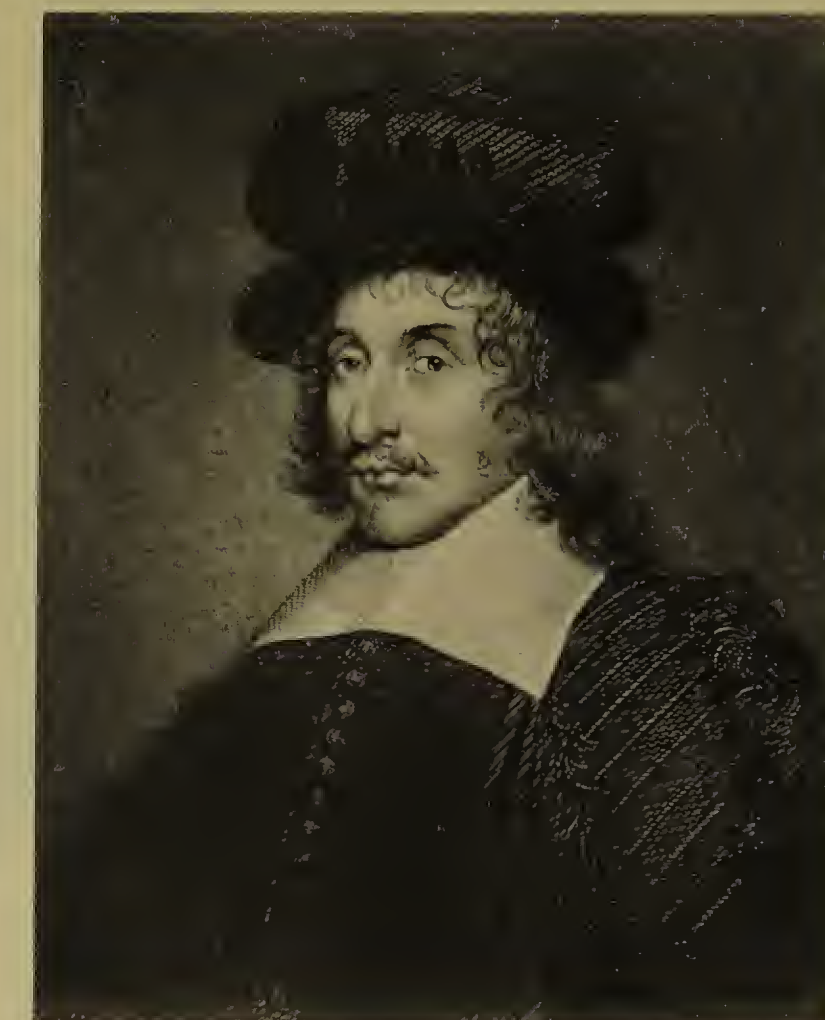
REGNER DE GRAAF.

1641-1673 (æt. 32).

THIS brilliant pupil of F. Sylvius was born at Schoonhaven, and practised at Delft, where he died in 1673, a year after his master, whose Chair he felt himself unable to accept. When a student, and as yet only twenty-three, he experimented on the pancreatic juice, made a temporary fistula, and collected the juice. The figure reproduced shows in part how the juice was collected, very much as it was collected by subsequent observers. It is interesting to note that a similar receptacle is shown in connection with the parotid duct. By the same method he also obtained bile from the bile duct, but Malpighi, before this, had made a biliary fistula. He published his observations, *Disputatio medica de natura et usu Succi Pancreatici*, 1664. In the case of the pancreas he notes that only a small quantity of juice was obtained, which agrees with modern observations on fistulæ made in a somewhat similar manner. The

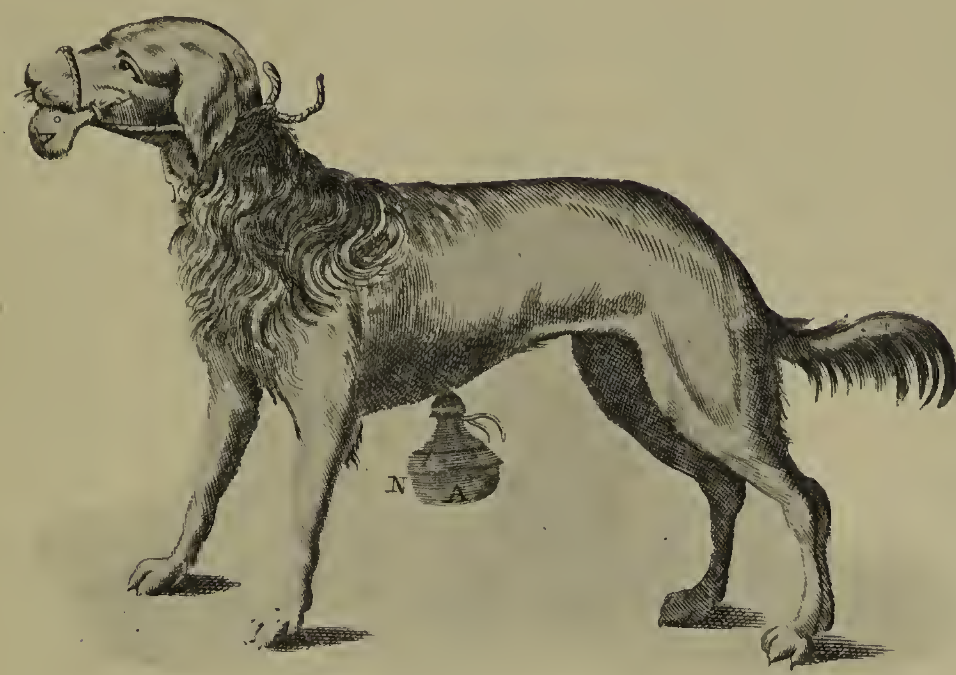
N. STENSEN.

TH. BARTHOLINUS.



TH. WHARTON.

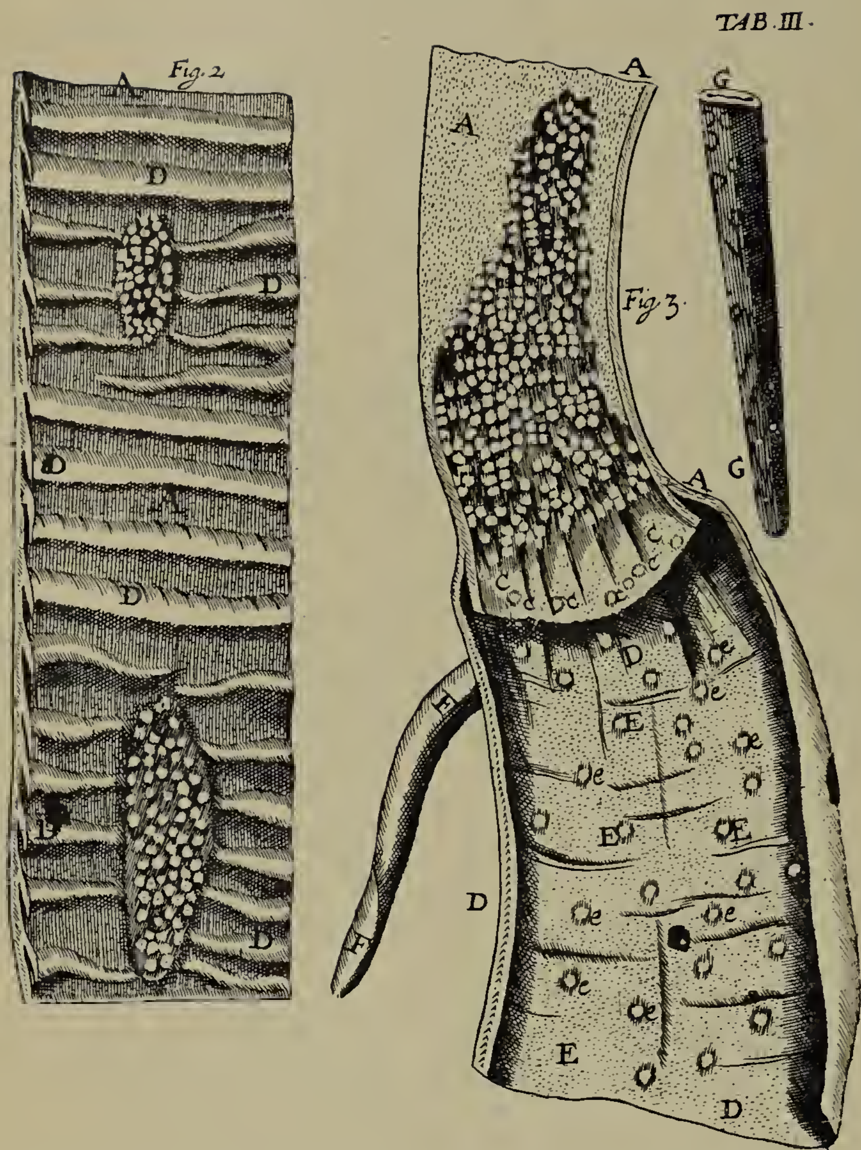
whole subject remained untouched after De Graaf, until it was taken up again by Cl. Bernard.



DOG WITH A PAROTID AND A PANCREATIC FISTULA, SHOWING VESSELS (A,A) FOR COLLECTING THE SALIVA AND PANCREATIC JUICE RESPECTIVELY. IT IS TAKEN FROM THE ORIGINAL FIGURE BY DE GRAAF.

By taste alone the juice was determined to be acid. The discovery of the lacteals, and the presence in them of chyle, led Sylvius to think that all the nutritious matter of the food passed that way to reach the blood. De Graaf, in 1668, gave an excellent account of the structure of the testis, as consisting of tubules folded up in lobules. His name is more familiar in connection with the ovarium, although this term is said to have been first applied to it by Steno (*Myol. Specimen*, p. 145). De Graaf appears to have been the first to describe its structure, and the vesicles that still bear his name, and the changes they undergo in different periods of gestation (*De mulierum Organis Generat. inserv. tract. novus*, Lugd. Bat. 1672). These vesicles received their present name from Haller, who called them *ova Graafiana* or *vesiculæ Graafianæ*.

The story of the discovery of the gland we now know by the name of Peyer is interesting. JEAN CONRAD PEYER was born at Schaffhausen, in Switzerland, where he practised, dying there in 1712. He tells us that he saw these glands scattered in definite portions over the small intestine, some singly, some in groups. He thought each had a pore at its summit and that they were secretory (or conglomerate) glands and not lymphatic (or conglobate). His view was that they secreted a digestive juice which is most useful in the lower part of the gut. I have reproduced his original figure from his work entitled *De Glandulis Intestinorum eorumque usu et affectionibus* (Amstel. 1681). In this connection it may not be without interest to reproduce a plate from N. Grew's work showing these



ORIGINAL FIGURE OF PEYER'S PATCHES C IN THE SMALL, AND SOLITARY FOLLICLES E IN THE LARGE INTESTINE.

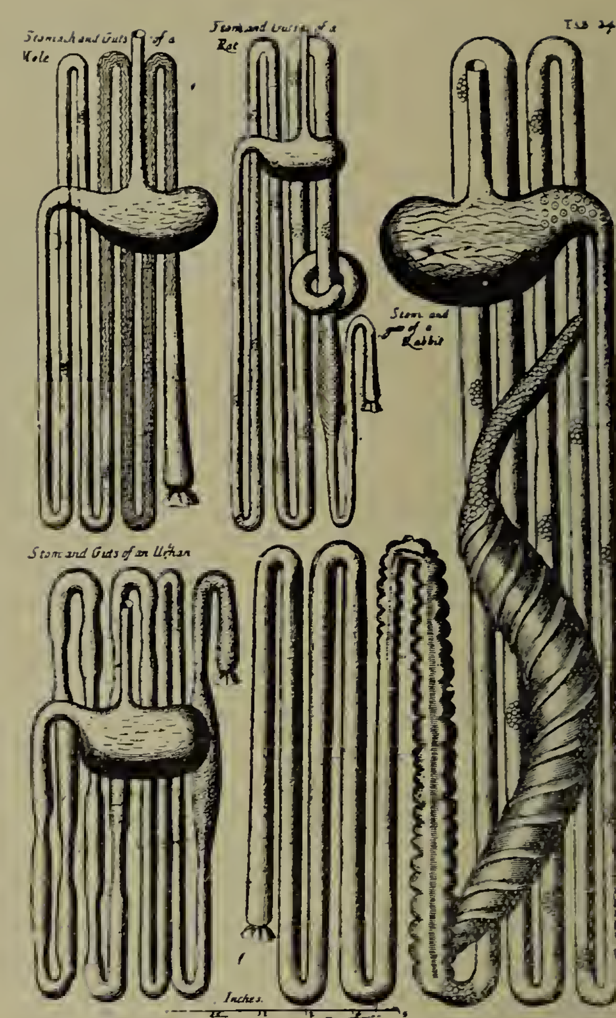


FIGURE SHOWING LENGTH, DIAMETER, AND OTHER CHARACTERS OF THE INTESTINAL CANAL OF SOME ANIMALS. OBSERVE PEYER'S PATCHES—N. GREW.

patches in a rat and rabbit. In fact these old figures are particularly instructive, as they give the length, size, and proportion of the several parts of the intestinal tract in a way that appeals to one far more vividly than the mere citation of numerical data. Peyer also wrote an excellent account of the anatomy of the intestine of the fowl, and also on *Merycologia, sive de Ruminantibus* (1685), or Rumination.

Born at Dieffenhofen in the same year as Peyer, JEAN CONRAD BRUNNER, who studied at Strasburg, discovered in the wall of the duodenum of the dog and man, about 1672, the glands that bear his name. He subjected the gut to the action of boiling water. (*De Glandulis in duodeno intestino detectis,* Heid. 1687). He published his results on the pancreas in 1682 (*Experimenta nova circa pancreas*). In 1687 he became Professor of Medicine in Heidelberg, a post he held for a year, and then settled in Mannheim, and later on was ennobled as "Brunn von Hammerstein," and died in 1727. His inaugural dissertation at Heidelberg is entitled *Dissertatio inauguralis de Glandulis Duodeni.* He speaks of these glands as yielding a juice like that of the pancreas and of them as a *pancreas secundarium.*

He removed the pancreas and the spleen as well, but not the whole of it, from a dog, which he kept alive for a time. According to him, in this dog the digestive functions were performed normally. If this be so, then it is plain that the pancreas could not have the high importance attributed to it by Sylvius and De Graaf. In one dog he observed great thirst and frequent micturition, and in another a ravenous appetite. All these statements are intensely interesting in the light of what we now know regarding the sinister effects of complete removal of the pancreas.

In connection with the digestive process itself, some held that it was due chiefly to the stomach, others to the bile, and some that it was chiefly due to trituration, others to concoction and chemical changes. Borelli long ago had experimented on birds provided with gizzards, *e.g.*, turkeys, in which he showed that glass spheres, hollow lead tubes, filberts, and nuts were crushed by the powerful action of the gizzard. He even calculated the force of the turkey's stomach at 1,350 lbs. In those animals not so provided, flesh and bone introduced into the stomach are consumed by a very potent ferment. The school of Sylvius—the iatro-chemists—contended that the changes were mainly chemical. Here the story is interrupted again for a long time, for GEORG ERNESTUS STAHL (1660-1734) added nothing to our knowledge of this subject. With his doctrine of "Phlogiston," and his "Animism" and "vital principle," or, rather, "sensitive soul," he retarded, rather than advantaged, progress. Two other observers, taking up the method of Borelli, added considerably to our knowledge of the process of digestion, more especially in birds.

HERMANN BOERHAAVE.

1668-1738.

TRACING the story from the end of the seventeenth to the eighteenth century, next to Stahl, the dominant and outstanding personality is Boerhaave, who, like Vesalius, was born as one year was shortly to pass into a new one, on December 31st, 1668, at Voorhout, near Leyden. His father was a clergyman, and Boerhaave's training at Leyden was such as to prepare him for the Church. After the death of his father, he taught mathematics in order to enable him to complete his studies in divinity. He became Doctor of Philosophy in 1690. Vanderberg, the burgomaster, advised him to study medicine. Boerhaave had a long-standing ulcer in the leg, which he cured by the application of a rather homely remedy. This result, it is said, along with an interlude of a different kind,

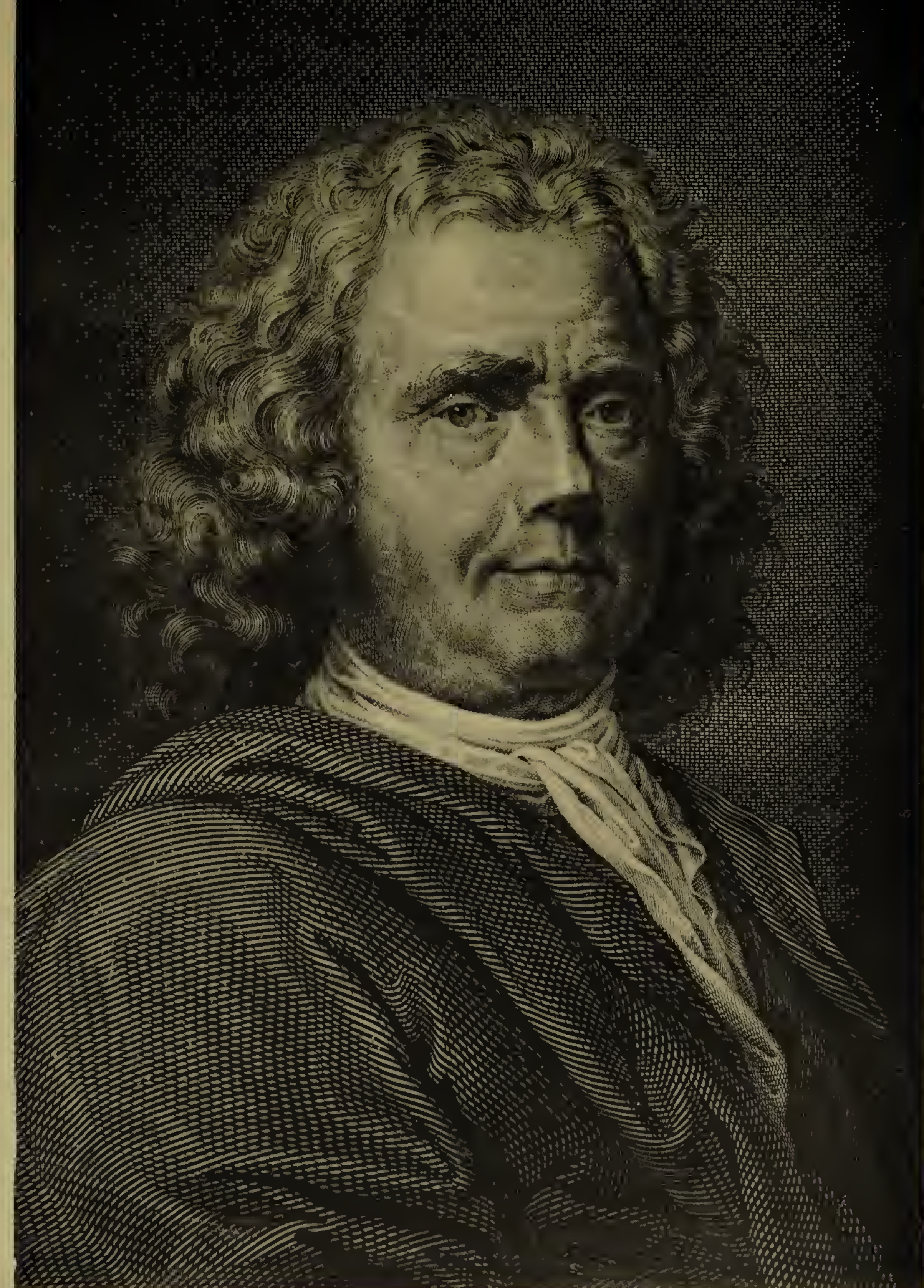
determined his action. He entered into a dispute with some one on a public track-boat about the doctrines of Spinoza, and he was by-and-by regarded as a Spinozist, although, in his thesis of 1690—*De distinctione Mentis a Corpore, The Distinction between Body and Mind*—he had vigorously assailed the doctrines of Spinoza. He studied hard, and appeared to have acquired his knowledge largely by private study, though he appears to have attended the course of Drelincourt and Nuck. He took the degree of M.D. in the University of Harderwick in 1693. In 1701 he succeeded Drelincourt, first as Lecturer, and, in 1709, as Professor of Medicine and also of Botany, as successor to Hotton. His success, as a lecturer and teacher, was such that the authorities increased his emoluments, and gave him unlimited scope for his unbounded energy, by making him, in 1715—after Bidloo's death in 1715—Professor of Practical Medicine, and, in 1716, Professor of Chemistry as well, as successor to Le Mort. Indeed, he was a whole "Medical Faculty in himself." In 1710 he published his *Index Plantarum*, but his two most famous books are his *Institutiones Medicæ*, &c., 1708—which passed through fifteen editions—and his *Aphorismi de cognoscendis et curandis Morbis*, &c., 1709. These for long formed the leading text books on these subjects in all the Schools of Europe. In 1731 his *Elementa Chemicæ* appeared. Already, in 1712, his reputation was so great that, on his recovery from his first severe attack of gout, the town of Leyden was illuminated and a general holiday declared. In 1729 he gave up the Chair of Botany and Chemistry. In 1730 he was admitted to the Royal Society of London. He died, with the symptoms of hydrothorax, on September 23rd, 1738. He assisted in the re-publication of many works of the older anatomists : Eustachius (1707) ; Vesalius, jointly with B. and B. S. Albinus (1725), but probably the latter wrote most of the additions (the plate marked "Vesalius Demonstrating" is from this edition) ; Bellini, *De Urinis, Pulsibus* (1730) ; J. Swammerdam, *Historia Insectorum, sive Biblia Naturæ* (1737), a work to which we have already referred.

RENÉ A. F. DE RÉAUMUR.

1683–1757.

TOWARDS the end of the seventeenth century there was born in the old Huguenot town of La Rochelle—famous in scientific story as the place where Walsh made his first experiments on electrical phenomena of the torpedo (1773), and in political history by its famous siege—one who stands out as one of the most versatile and strikingly original scientific men of all time. His private means

VAN HELMONT.



H. BOERHAAVE.

A. HALLER.

were ample, and he studied just to please himself. During his school holidays, as he lived near the sea, he studied the murex, that yields the Tyrian purple, the process of reproduction of lost limbs in crabs, the movements of star fishes, phosphorescence (1708–1715). Already his scientific bias declared itself. He in later life made important contributions to the problem of the manufacture of steel and tin-plating, to the making of porcelain (1735), and devoted much attention to forestry. His observations on the silk of spiders were made in 1714. The thermometer which bears his name was invented in 1731. His other great works were *Insects*, in 1737–48 (12 vols.); *Incubation of the Chick*, and, what concerns us most, *Sur la Digestion des Oiseaux* (Digestion of Birds), *Mem. des Acad. des Sc.*, Paris 1752, p. 266, though the work was begun in 1749. He was killed by a fall from his horse in 1757.

He made use of a fact in comparative anatomy, viz., that certain birds regurgitate the indigestible parts of their food. He gave to a tame kite metal tubes—containing flesh, starch, bone, or other substance—and provided with a grating of threads at both ends to prevent the escape of the contents. He found that the contents of the regurgitated tubes were in part dissolved, and what remained showed no sign of putrefaction. Filling such tubes with sponge, he was able to obtain a small quantity of gastric juice—which he found turned blue paper red. This juice he used to try what we now know as artifical digestion *in vitro*, and found that meat was partially dissolved thereby and that there was no putrefaction. It was evident, then, that gastric digestion was not due to trituration of the food, that it was not a putrefactive process, but that the gastric juice had a solvent and, indeed, anti-putrefactive power. It was not until Spallanzani took up the subject again, that this subject was carefully investigated.

ALBRECHT VON HALLER.

1708–1777.

I HAVE purposely passed over the views of Boerhaave on physiological problems. He held a sort of even balance between the iatro-mechanical and iatro-chemical schools. It was his *Institutiones Medicæ* which secured him one of his most brilliant pupils, of whom we shall speak next. Indirectly, therefore, the MSS. of Vossius, the kindly advice of a burgomaster, and a dispute about Spinoza led Boerhaave to medicine, and the latter's "Institutions" led Haller to Leyden.

It was a matter of great importance to the development of physiology that the fame and works of Boerhaave attracted to

Leyden one who has been called the "Father of experimental physiology" viz., A. von Haller. He was born at Berne in 1708.

The precocity of the youth, the versatility of his talents, and his extensive acquirements, while apparently fitting him for any profession, rendered the choice of a career somewhat difficult. Fortunately he had a bias towards medicine, and in 1723 he decided to study at Tübingen. As showing the influence of Boerhaave on Haller, who had used his "Institutes" recommended by one of his teachers—Duvernoi—Haller, in 1725, went direct to Leyden to continue his studies under the master himself at a time when Boerhaave was in the full plenitude of his powers. There also he sat under B. Albinus (primus), and had as a fellow-student F. B. Albinus, who succeeded his father as Professor of Anatomy in 1745. Doubtless also he learned something from the already aged Ruysch. He took his M.D. in Leyden in 1727, and then spent some time in travel, visiting England, and then Paris, where he made the acquaintance of Winslow, the Professor of Anatomy. He next returned to Basel in 1728, where he devoted a considerable amount of time to the muses and to botany, studying under Bernouilli. In 1730 (æt. 22) he returned to his native city, where he practised medicine, studied and taught anatomy (from 1734) until 1736, when George II., as Elector of Hanover, offered him a Chair of Anatomy, Surgery, and Botany, in the newly founded University of Göttingen—an offer which he accepted. He met with an accident on the way, and his wife was fatally injured.

In Göttingen he laboured seventeen years, chiefly at physiology, where he had Zinn as a pupil, returning to Berne in 1753, where he lived and wrote for nearly another quarter of a century, publishing in 1757 the first volume of his *Elementa Physiologiæ*, and the last or eighth volume in 1765. This great compendium marks the beginning of modern physiology. His industry must have been immense, for every page bristles with references to preceding works, and the work itself may be taken as comprising the fullest embodiment and representation of all that had been taught in physiology up to that time. Careful anatomical descriptions are followed by physiological expositions and then on both a critical judgment with suggestions as to what is required to complete the picture. His chief claim to glory is his *Elementa*, which contains all the facts, theories, and bibliographical references of preceding observers. His knowledge was encyclopædic, his tastes catholic, his aspiratious poetical, and he was supremely devout withal.

On the death of Dillenius, he was invited to occupy the Chair of Botany at Oxford, but declined.

Like his master, Boerhaave, and like Harvey, and so many more of the fraternity, he was a martyr to gout. Sincerely devout, and

possessed of abiding religious faith, he met his end, perhaps, as few ever did. Rosselot, his physician, attended him to the last. Haller felt his own pulse from time to time, and, addressing his friend and physician with the utmost composure, said, "The artery no longer beats." Thus passed away on December 12th, 1777, this "Prince of Physiologists," the year which marks also the death of Linnæus and Jussieu, Voltaire and Rousseau. "Science and literature have rarely lost such splendid ornaments in so short a period of time" (T. J. Pettigrew).

Perhaps, his greatest work is that on the doctrine of muscular irritability. Glisson, as we have seen, introduced this term, using it in a broad sense. He established the fundamental fact that the "irritability" or excitability of a muscle, or *vis insita* or "inherent force" as he calls it, is a property dependent on the muscle itself, and not on the influence of the nervous system. We need not enter here into his long discussion with Robert Whytt, of Edinburgh, who maintained the opposite proposition. All this dates from 1739 to 1743. The power by which muscles are called into action through the nerves he calls the *vis nervosa*, which, like the *vis insita*, survives somatic death, for a muscle of a frog can be thrown into action when its nerve is irritated. He distinguishes "sensibility" from "irritability," and in his paper on "Sensibility," read 22nd April, 1752, in Göttingen, he states how since 1751, "j'ai sousmis à plusieurs essais 190 animaux; espèce de cruauté pour laquelle je me sentais une répugnance qui n'a pu être vaincue que par l'envie de contribuer à l'utilité du genre humain." The second paper, on "Irritability," was read 6th May, 1752. Any one wishing to read these famous memoirs will find them reproduced by my friend Charles Richet, Professor of Physiology in the Medical Faculty of Paris, in his *Les Maîtres de la Science: Bibliothèque rétrospective* (1892).

Besides his *Elementa* Haller's chief works are, *Sur la formation du Cœur dans le Poulet* (Lausanne 1758); *La Nature sensible et irritable des parties du Corps animal* (Lausanne 1760); *Mouvements du Sang et la Saignée* (Lausanne 1757); *Formation des Os* (1758); *La Génération* (1758); *Collections de thèses de Médecine, de Chirurgie, et d'Anatomie*, 13 vols. 4to (1757–1778).

WILLIAM CULLEN.

1712-1790.

BORN in 1712 at Hamilton in Lanarkshire, he studied at Glasgow University in 1727, went to London in 1729, visited the West Indies as a surgeon on a merchant ship; he returned to Scotland in 1731, attended the University of Edinburgh (1734-1736), was one

of the founders of the Royal Medical Society of that city (1737). He practised as a surgeon in Hamilton in 1736, and took his M.D. in Glasgow in 1740. He removed to Glasgow, where he practised his profession and lectured on medicine, botany, and materia medica, and chemistry, and became Professor of Medicine in Glasgow University. He was the first to give up lecturing in the Latin tongue. He was elected to the Chair of Chemistry in Edinburgh by the Town Council in succession to Dr. Plummer in 1755, a post he held for ten years. He also lectured on clinical medicine in the Royal Infirmary, and had as colleagues Dr. R. Whytt and Professor Monro, and he succeeded, on the death of Whytt in 1766, to the Professorship of Institutes of Medicine. The Chair of Chemistry was then filled by his pupil Black. For a time he was co-professor with Gregory. He resigned in 1789, and was succeeded by Dr. James Gregory. He died in 1790 æt. 78.

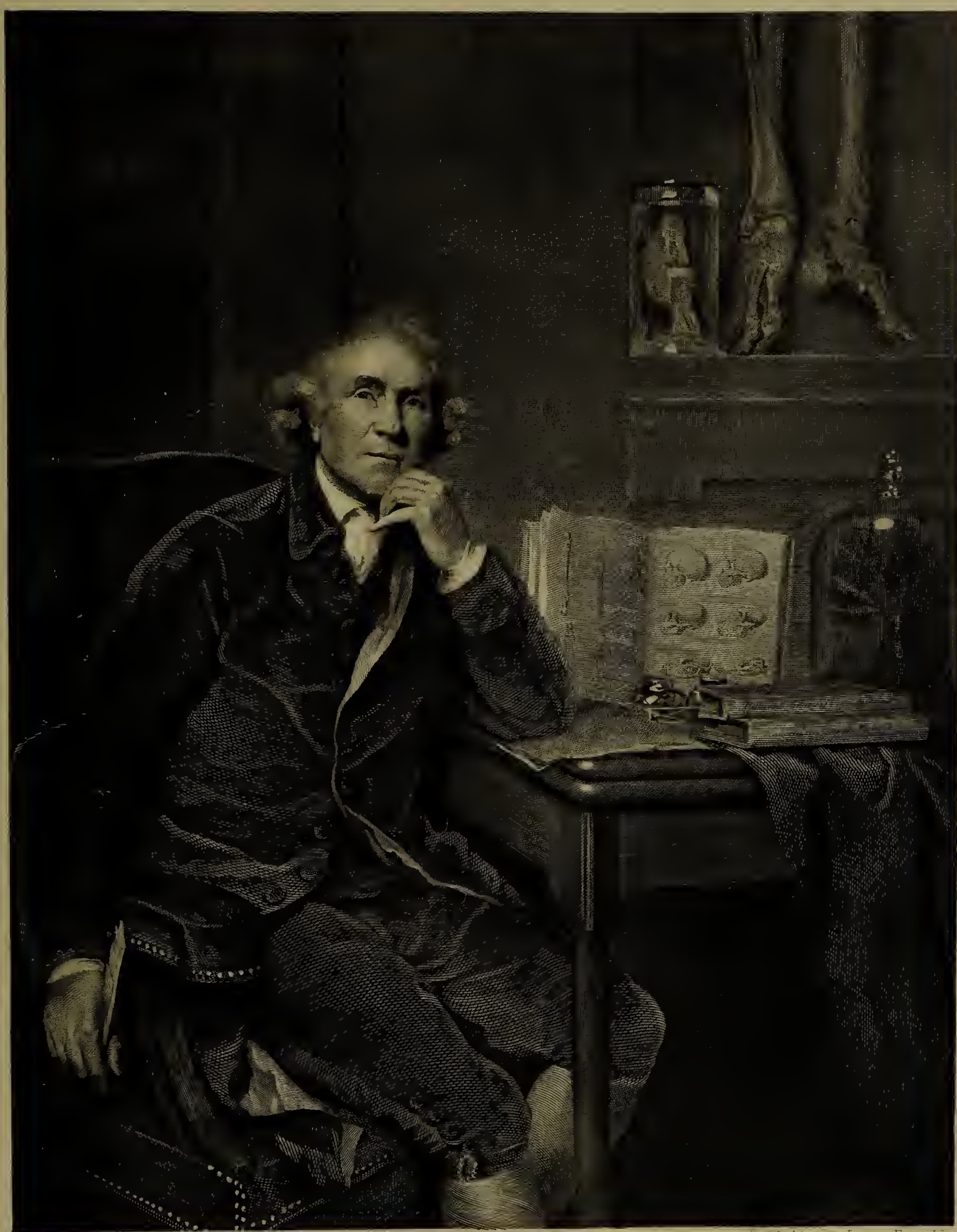
JOHN HUNTER.

1728-1793.

THE immortal John Hunter was born at Long Calderwood, the youngest of ten children. His brother William had early migrated to London, and was not only a successful practitioner there, but was lecturer in the Windmill Street School of Medicine. John, who had passed three years in a workshop in Glasgow, joined him in 1748 as an assistant in the School of Anatomy. In 1754 he entered as a pupil in St. George's Hospital, becoming house-surgeon in 1756. In 1761 he became an army surgeon and went to Belleisle and Portugal where he remained three years, his place as assistant to his brother being supplied by Wm. Hewson. WM. HEWSON was born at Hexham, 1739, and, when he came to London, lived with John Hunter, taught anatomy, and had a department in Windmill Street with Wm. Hunter. His chief works—and some of them are classical—deal with the *Blood, Lymphatic System in Birds, Lymph, Red Particles of Blood.* See *Works of W. Hewson,* by Geo. Gulliver (New Sydenham Soc., 1846). He died on May 1st, 1774, from the results of a dissection wound at the early age of thirty-five.

On his return to England, Jack Hunter, as he was called, settled in London, lectured on practical anatomy, surgery, dissected, collected, built a house at Earl's Court for keeping his strange collection of living animals, and at the same time followed the practice of his profession.

In 1776 he was appointed surgeon extraordinary to the King. He removed to Leicester Square in 1783 and erected a building for his collection of all kinds of preparations—anatomical and pathological —human and comparative.



Photogravure by Annan & Sons, Glasgow. Painted by Sir Joshua Reynolds

JOHN HUNTER.

He first tied the femoral artery for popliteal aneurism in 1785. In 1786 he became Deputy Surgeon-General to the Army.

He suffered from angina pectoris and died with awful suddenness on October 16th, 1793 (æt. 65), at St. George's Hospital, where he went to attend a meeting. His pupil, Ed. Jenner, may be said to have been the first physician in England to diagnose this disease.

The Hunterian Museum is his great memorial; his own part of it cost him in money alone £70,000. It was purchased by the Government for £15,000, and presented to the corporate body that, in 1800, became the Royal College of Surgeons. It would take several pages even to enumerate the titles of his works, but some of his views on special subjects are referred to elsewhere. There are numerous and easily accessible biographies. The museum and collections of his brother William are the property of the University of Glasgow.

The portraits reproduced of John Hunter are two, in photogravure. One is the well-known portrait by Sir Joshua Reynolds, the other is new. It is taken from a photograph given to me by the late Sir Henry Acland, of Oxford. The statue was presented by the late Queen, Her Majesty Queen Victoria, to the Museum of Oxford, and forms one of a beautiful series of statues that adorn that most delightful and resposeful Valhalla. It was executed by Mr. H. Richard Pinker. In the words of one who has a profound admiration for John Hunter, "Reynolds gives the thinker; this gives the fighter, physically as well as mentally."

We need only recall one or two incidents connected with the life-work of WILLIAM HUNTER, the brother of John.

WILLIAM HUNTER was born in 1718 and died in 1783. His remains are buried in the rector's vault of St. James's Piccadilly—a hero amongst his compeers—having on one side of him the English Hippocrates, Thomas Sydenham, and on the other Richard Bright.

William, after leaving college, fortunately for medicine, did not obtain the post of schoolmaster in his native parish, and this incident recalls the fact that another great Scotsman—Sir James Young Simpson—fortunately for medicine and humanity, did not get a small post he sought in a small village near the Clyde. SIMPSON'S name must ever remain associated with anæsthesia and chloroform (1847).

The story of the "two Williams," Wm. Cullen and Wm. Hunter, will be found in John Thomson's *Life of Cullen* (1832).

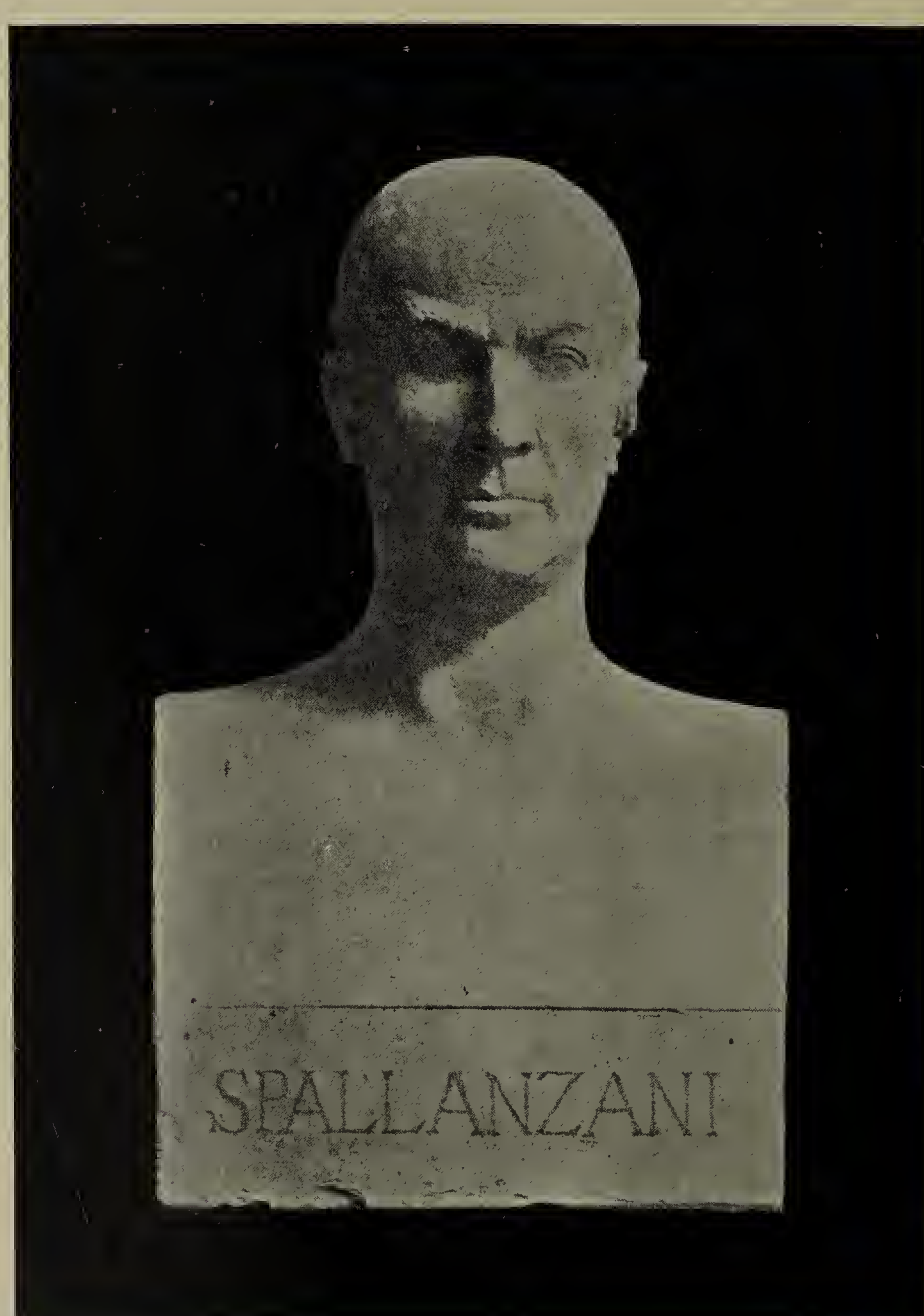
Cullen, at one time a country practitioner in a small town in Lanarkshire, whose name is intimately linked with that of the Hunters and Black, acquired a European fame.

LAZZARO SPALLANZANI.

1729-1799.

MORE frequently spoken of as the Abbé, for he took orders, but his bias was towards natural history. It was only the other day that his compatriots in Science celebrated the first centenary of his death by issuing a volume of contributions in his honour. The collotype is taken from the profile drawing in this volume issued at Reggio-Emilia on this occasion. The figure of the bust of Spallanzani adorns the Scuola called after him in the new Physiological Laboratory of the University of Modena. I owe it and several others to the kindness of Professor Mariano L. Patrizi, of Modena.

Born at Scandiano in Reggio-Emilia, the son of a celebrated advocate, he received a liberal education with a view to his entering the legal profession. He studied law in Bologna, there also he studied mathematics under his cousin, Laura Bassi, "a woman justly celebrated for her genius, her eloquence, and her knowledge of physical



FROM A BUST IN THE INSTITUTE OF PHYSIOLOGY IN THE UNIVERSITY OF MODENA.

and mathematical science," and one of the most illustrious Professors in Bologna (J. Senebier). Vallisnieri, Professor of Natural History, Padua, advised him to study natural history, and his father consented to his following the bent of his own inclinations.

From 1754 to 1760 he was Professor of Logic, Mathematics, and Greek at Reggio in Lombardy, and then of Natural History in Modena, where he remained until 1768, when he accepted the corresponding Chair in Pavia, where he died in 1799; his physician was the illustrious Scarpa. He journeyed much, and collected much, for he was essentially a great naturalist of the widest sympathies. In 1765 he published his *Saggio di Osserv. microscop. concern. il systema di Needham e Buffon,* in which he established the animal nature of animalculæ, and their development from pre-existing parents; and showed that there was no such thing as a spontaneous generation of these creatures. His remarkable work, *Sopra le riproduzioni animali,* surprised the scientific world. He proved that reproduction of lost parts in animals—the head in snails, limbs in newts, &c.—could take place to an extent hitherto unacknowledged. He also made some remarkable observations on the circulation of the blood, incited thereto by reading the works of Haller.

In his *Opuscoli di fisica anim. e vegetabile* (Modena 1776), he deals with the problems of generation already mentioned. It is in his *Dissertazioni di fisica animale e vegetabile* (1783) that he deals with the problems of digestion. He started where Borelli and Réaumur left off, using metal tubes, which he introduced into the stomachs of animals, carnivorous or otherwise. He also experimented on himself by swallowing meat or bread, wrapped up in linen. He obtained gastric juice and studied its effects *in vitro,* keeping the juice warm and placing in it bread, meat, grains, and observing the effects of artificial digestion. He used water added to the meat or bread as a control test. He found that this juice dissolved flesh, bones, bread; that some parts were more readily dissolved than others. There was, moreover, no putrefaction. Indeed, when opening a snake several days after it had fed, he got no trace of putrefaction in the still unconsumed cadaver in the stomach.

As to the cause of the solution, the absence of signs of putrefaction showed that it could not be due to this process; in fact, putridity in meat was arrested or set aside by action of "the something" he used and regarded as gastric juice. He knew that the juice coagulated milk, but as yet there was no proof of the acidity of the juice, far less of its acidity being due to a mineral acid. That discovery was reserved for W. Prout (1824). There is an excellent English translation by one "who chooses to conceal his name." In the introduction Spallanzani states that:—

"In the course of my public demonstrations in the year 1777, I repeated in the presence of my hearers those celebrated experiments of the Academy of Cimento, *i.e.*,

those of Borelli—that show the astonishing force with which the stomachs of fowls and ducks pulverize empty globules of glass in the space of a few hours. . . . . I conceived the design of extending them to birds with muscular stomachs and gizzards . . . . then to animals with membranous stomachs . . . . not neglecting man, the noblest and most interesting of all."

The work contains six dissertations with two hundred and sixty-four paragraphs, each one following the other with logical precision, and giving exact accounts of the order of experimentation, the results, and Spallanzani's deductions from them. Every student of medicine should read the dissertations.

I can, perhaps, best sum up Spallanzani's work by epitomizing the letter of the veteran Professor A. v. KÖLLIKER written "in honour of the great Lazzarus Spallanzani."

"In connection with the physiology of reproduction, I regard the following as the chief contributions of Spallanzani :—(1) He by means of beautiful experiments, if not absolutely proving, at least made exceedingly probable the view that protozoa which develope in infusions, only do so when it is possible for germs to pass into them from the air. (2) He proved that the tail and limbs of tritons could be reproduced. In 1764 he had observed that snails could reproduce even their head if it was cut off. He also made important discoveries by artificial impregnation of the ova of amphibia. His observations on spermatozoa, and especially those with the filtered fluid, showed that the spermatozoa alone are the fertilizing male element—a fact which remained unconfirmed until it was again proved in 1824 by Prevost and Dumas. The most important, however, was the artificial impregnation of a bitch, a fact confirmed by Professor P. Rossi in Pisa in 1782."

"Dealing with Spallanzani's observations on digestion, the most important points are :—(1) The digestive juice alone digests, and the muscular apparatus has no direct influence on digestion. (2) He obtained natural gastric juice by introducing sponges attached to strings into the stomachs of living animals, and in the same way obtained the fluid of the crops in birds. (3) He made experiments outside the body with the juice thus obtained, and showed its activity. (4) He also experimented with his own gastric juice and on his own digestive processes. (5) He made an enormous number of experiments of a comparative nature on the most different animals, frogs, salamanders, snakes, fish, &c. ; on the action of the gastric juice on all possible kinds of food, animal and vegetable, bone, &c. (6) Lastly he obtained a large quantity of gastric juice from a crow, on which his friend Scopoli was able to make the first chemical analysis of this fluid."

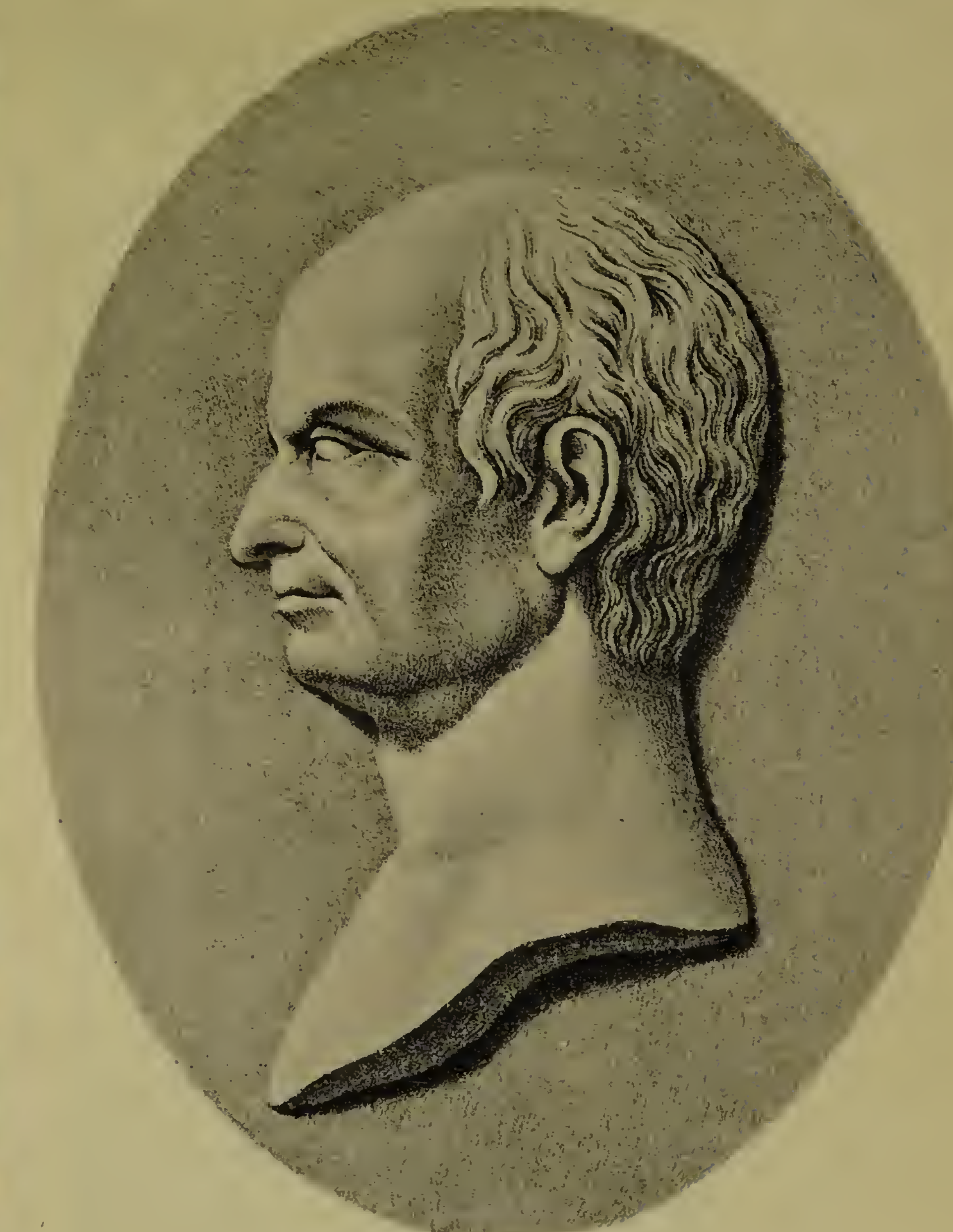
His remarkable observations on Respiration, which bridged over a great gap left by Lavoisier, are referred to in another place.

In the same year as Spallanzani published his *Opuscoli,* a thesis for the degree of M.D. was presented to the University of Edinburgh by E. STEVENS, *De alimentorum concoctione Diss.* (Edin. 1777). This is translated and appended to the Dissertation of Spallanzani already referred to.

"The experiments were made at Edinburgh upon a Hussar, a man of weak understanding, who gained a miserable livelihood by swallowing stones for the amusement of the common people. He began this practice at the age of seven, and has

L. GALVANI.

R. A. F. REAUMUR.



L. SPALLANZANI.

now followed it twenty years. His stomach is so much distended, that he can swallow several stones at a time; and these may be not only plainly felt, but may be heard, whenever the hypogastric region is struck."

Stevens used hollow silver spheres perforated with fine holes, which he filled with all sorts of food, animal and vegetable, fish and fowl, roast and boiled, even live worms and leeches, and these spheres were swallowed by this person, and when voided—usually in from twenty to forty hours—any changes in the nature and weight of the contents were noticed. The Hussar left Edinburgh, and Stevens had recourse to dogs and ruminants. He also used ivory balls and was surprised to find that they were dissolved by the gastric juice of a whelp. He practically arrived at the same results as Spallanzani, for his experiments

"show that digestion is not the effect of heat, trituration, putrefaction, or fermentation alone but of a powerful solvent, secreted by the coats of the stomach which converts the aliment into a fluid resembling blood. If it should be asked what defends the organ itself, I would answer that it is the vital principle, as Mr. Hunter's observations show; after death it is dissolved as readily as any other inanimate substance."

Here we must again refer to JOHN HUNTER, who found digestion of the posterior wall of the stomach in several cases where the person had died suddenly, usually after a full meal. The first case was recorded at the instance of Sir John Pringle. Others after fracture of skull, *i.e*, after sudden violent death, he met with in his own practice. His results he recorded in *On the Stomach itself being digested after death*, in *Phil. Trans.* LXII., p. 447, 1772. He recurs to this subject in a paper entitled *Some Observations on Digestion* in his *Observations on certain parts of the Animal Economy*, dated from Leicester Square, 1786.

All his observations led him to a more decided confirmation of his views of the existence of a "vital principle." He saw clearly enough that "the digestion of the wall of the stomach after death shows that digestion neither depends on a mechanical power—the old trituration—nor contraction of the stomach, nor on heat, but on something secreted in the coats of the stomach . . ." It remained for Bernard to give an excellent and simple demonstration of this process in a rabbit killed during digestion. Hunter's idea of a living hand and a dead one introduced into the stomach was met in a different way many years later by Bernard, who used the leg of a frog, and F. W. Pavy, who used the ears of a rabbit; but these experiments were only possible after the invention of gastric fistulæ.

These *Observations* are most interesting, but Hunter goes out of his way to say ungracious things of Spallanzani and others. He speaks of the nature of their education—"of views that few will subscribe to"—of the clergy as philosophers and physiologists. He must

have been in one of his irritable moods. He will have none of Spallanzani. The article, of course, shows his intimate knowledge of comparative anatomy. He even says :—" The stomach appears not only to be capable of generating an acid, but air, the latter in disease." He speculates as to the blood being the source of this air. He "is inclined to suppose an acid in gastric juice as a component or essential part of it." He tested it with syrup of violets, which became red. Gastric juice coagulates milk and white of egg. "It is not the digestive power which coagulates milk, complete coagulation takes place even where digestion does not at all go on." This is a remarkably shrewd observation, in view of what we now know regarding pepsin and rennin. He records the fact that, while stationed at Belleisle, he introduced worms into the stomachs of animals, and observed the effects of heat and cold on the process of digestion.

To complete the story, perhaps the best way will be to quote Senebier's *Life of Spallanzani* :—

"Some experiments made by Spallanzani upon digestion, for the purpose of his lectures, induced him to study this obscure process. He repeated Réaumur's experiments on gallinaceous birds, and he observed that, in this case, trituration is an end, without being the means, of digestion. He found the gizzard of those animals, which pulverizes walnuts and filberts, and even lancets and needles, does not digest the pulverized matter; that it must undergo a new preparation in the stomach, in order to form the alimentary pulp which contains the elements of the blood and of all the humours. He evinces that digestion is effected in the stomach of a multitude of different kinds of animals—insects excepted—by the action of a juice which dissolves the aliment; and, to render this demonstration more striking, he had the courage to make experiments on himself, which might have proved fatal to him, and address to complete his proofs by artificial digestions executed on his table in glass vessels, wherein he mixed the aliments with the gastric juice of animals, which he knew how to extract from their stomachs. But this book, so original, from the multiplicity of the experiments and observations which it contains, is still more deserving of attention from the philosophic spirit which dictates it. This work gave offence to John Hunter. I know not the cause of his displeasure. In 1786 he published his *Observations on certain parts of the Animal Economy*, in which he discharges some piercing shafts against Spallanzani, who avenged himself by publishing the work in Italian, and addressing to Caldani, in 1788, *Una Lettera apologetica in riposta alle osservazioni del signor Giovanni Hunter*, in which he repels, in a tone of moderation, but with an irresistible strength of reasoning, the affected disdain of the Engish physiologist, and demonstrates his errors so as to leave him no hope of a reply." (J. Senebier, in *Memoirs on Respiration by Spallanzani*. Trans. 1804.)

"Spallanzani was about the middle size; his gait was lofty and firm; his countenance dark and pensive. He had a high forehead, lively black eyes, a brown complexion, and a robust frame. He had never experienced, during his whole life, but one fever." (J. Senebier.)

JOSEPH BLACK.

1728–1799.

"No professor took a more lively interest in the progress of an emulous student than Dr. Cullen. It was his delight to encourage and assist their efforts, and therefore he was not long in attaching Mr. Black to himself, in his most intimate co-operation." (Professor J. Robinson's Preface to Black's *Lecture on Elements of Chemistry*.)

CULLEN was attracted by the teaching of Stahl, and for a time followed chemistry with ardour before he devoted himself to medicine. He was the teacher of Joseph Black, and Black became his successor—Black, "who first struck out a new and brilliant path, which was afterwards fully laid open and traversed with such *éclat* by British philosophers who followed his career."

Black's father—a wine merchant—was of Scottish descent, and he himself was born at Bordeaux, on the banks of the Garonne, in France, in 1728. In 1746 Black entered Glasgow University, and became assistant to Cullen. Black in 1750 went to Edinburgh to pursue his medical studies and there carried out investigations on limestone and quick-lime. He took his degree of M.D. in 1754, presenting, as his thesis, *Dissertatio de Humore acido a Cibo orto et de Magnesia.* The faculty at that time were discussing the action of lime-water as a lithontriptic. Limestone he showed to be a mixture of lime and an aereal substance to which he gave the name "fixed air" *i.e.*, carbonic acid. When Cullen became Professor in Edinburgh, Black succeeded him in Glasgow in 1759.

"His first appointment in Glasgow was to the Professorship of Anatomy, and the Lectureship on Chemistry. He did not consider himself as so well qualified to be useful in the former branch of medical study. . . . . He made arrangements with the Professor of Medicine, and, with the concurrence of the University, the Professors exchanged their tasks. His lectures, therefore, on the Institutes of Medicine were his chief task." (J. Robinson, Preface, xxix.)

It was in Glasgow that he made his famous investigations on heat and latent heat. In 1766 Cullen became Professor of Medicine, and Black succeeded him in the Chair of Chemistry. He died in 1799, peacefully, sitting at his frugal table, where he was found by his servant "with his cup—which contained milk diluted with water—on his knees, which were joined together, and kept it steady with his hand in the manner of a person perfectly at ease." His discoveries were all made before he reached the age of thirty-four. Black in Glasgow had as a pupil James Watt—who may well be called—

"Dr. Black's most illustrious pupil! for surely nothing in modern times has made such an addition to the power of man as Watt did by his improvements on the steam engine, which he professes to owe to the instructions and information received from Dr. Black."

Stahl's theory of phlogiston still held the field and enthralled the minds of chemists. Black found that when mild lime was burned, and caustic lime was formed, fixed air was given off. This led up to the important test of Black, viz., that when this fixed air is passed through a clear solution of lime-water a precipitate of what we now know as carbonate of lime is formed, *i.e.*, caustic lime combines with fixed air to form mild lime (1757).

He found that fixed air is given off during fermentation and in the expired breath, and is formed when charcoal is burned. He had rediscovered the *gas sylvestre* of Van Helmont.

Black's remarks on *Fixed Air* are worthy of being quoted.

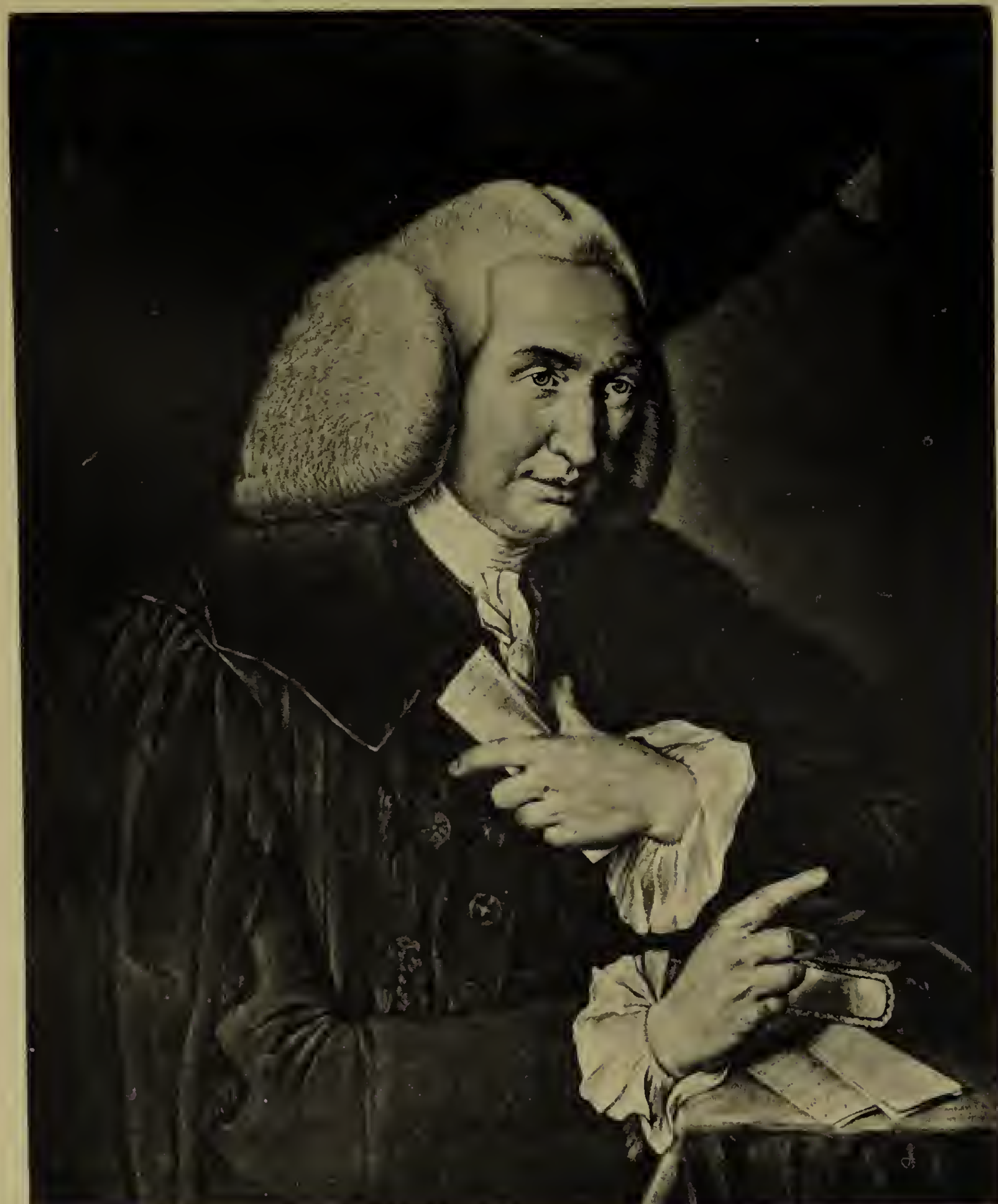
"Here a new and boundless field seemed to open before one. We know not how many different airs may be thus contained in our atmosphere, nor what may be their separate properties. This particular one has evidently very curious and important ones. . . . I fully intended to make this air and some other elastic fluid the subject of serious study. A load of new official duties was laid upon me [*i.e.*, he was elected Professor of Medicine and Chemistry in Glasgow]. In the same year, however, in which my first account of these experiments was published—namely, 1757—I had discovered that this particular kind of air, attracted by alkaline substances, is deadly to all animals that breathe it by the mouth and nostrils together; but that if the nostrils were kept shut, I was led to think that it might be breathed with safety. I found, for example, that when sparrows died in it in ten or twelve seconds, they would live in it for three or four minutes when the nostrils were shut by melted suet. And I convinced myself that the change produced on wholesome air by breathing it consisted chiefly, if not solely, in the conversion of part of it into fixed air. For I found, that by blowing through a pipe into lime-water, or a solution of caustic alkali, the lime was precipitated, and the alkali was rendered mild. I was partly led to these experiments by some observations of Dr. Hales, in which he says, that breathing through diaphragms of cloth dipped in alkaline solution made the air last longer for the purposes of life. . . . . In the same year I found that fixed air is the chief part of the elastic matter which is formed in liquids in vinous fermentation. Van Helmont had indeed said this, and it was to this that he first gave the name *gas sylvestre*." (*Treatise on Chemistry*, Vol. II., p. 87, 1803.)

We have already referred to the work of Boyle, and following the story of "fixed air" we next come upon the work of the HON. HENRY CAVENDISH (1731–1810).

"The great majority of the distinguished chemists of Great Britain have sprung from the middle or lower ranks of the people, but two of the most famous of them, the Hon. Robert Boyle and the Hon. Henry Cavendish, were men of illustrious lineage, and Cavendish was much the more high-born of the two."

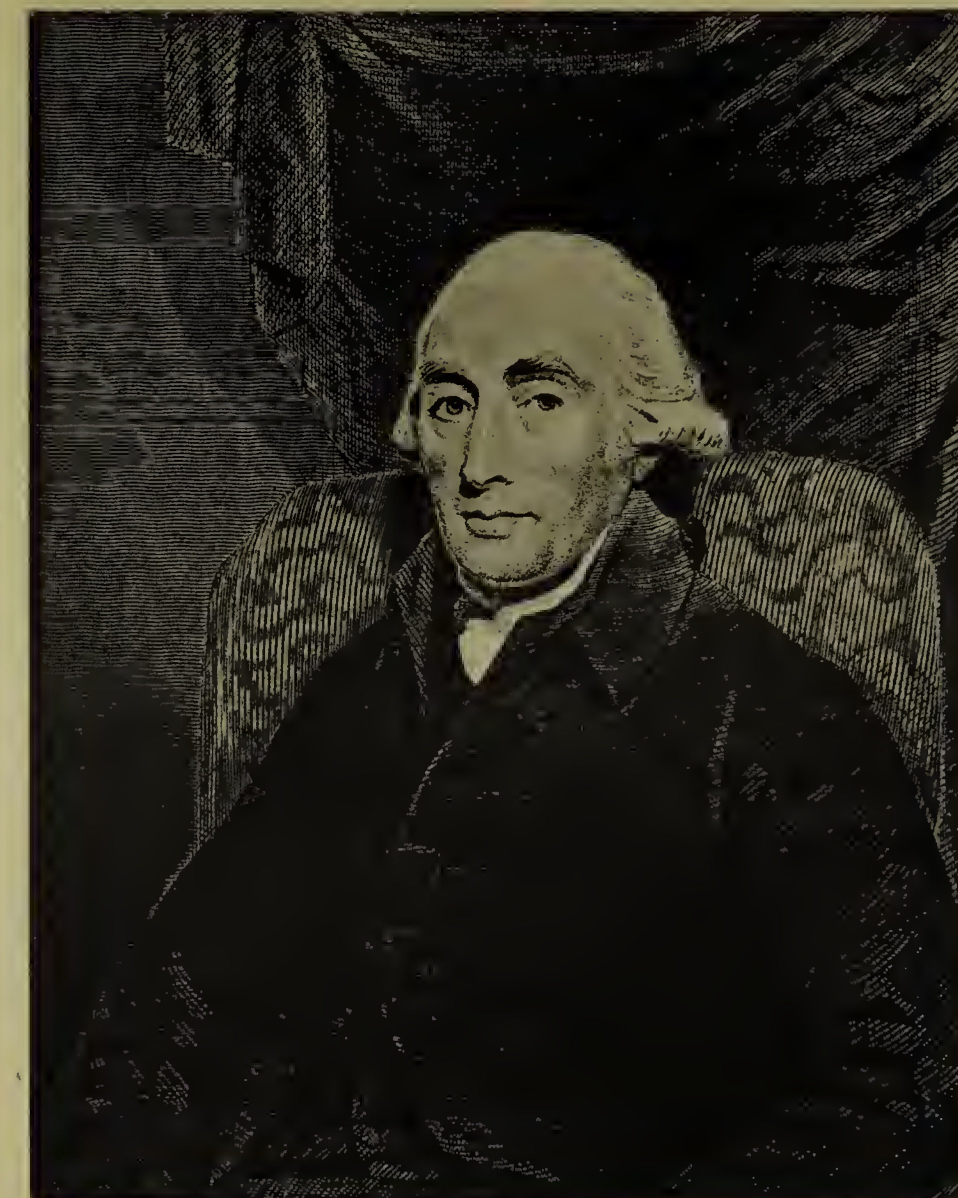
"Twelve years after the publication of Black's paper, in 1766, Cavendish published the first essay on *Factitious Airs.* He took up the investigation of fixed air where Black and his pupils had left it, and examined in particular its properties when free, on which Black had published scarcely anything."

"The operations of his intellectual powers exhibit a degree of *caution—cavendo tutus* is the motto of the family—almost unparalleled in the annals of science, for there is scarcely a single instance in which he had occasion to retrace his steps or to recall his opinions. (*Three Papers containing Experiments on Factitious Air, Phil. Trans.* 1766, p. 141.) It had been observed by Boyle, that some kinds of air were unfit for respiration;



W. Cochran Pinxit. T. Summers excudit. Val. Green fecit

W. CULLEN.



JOSEPH BLACK.

and Hooke and Mayow had looked still further forward into futurity with prophetic glances, which seem to have been soon lost and forgotten by the inattention or want of candour of their successors. Hales had made many experiments on gases, but without sufficiently distinguishing their different kinds or even being fully aware that fixed air was essentially different from the common atmosphere. . . . Dr. Seip had suggested that the gas which stagnated in some caverns near Pyrmont was the cause of the briskness of the water. . . . Dr. Black in 1755 had explained the operation of this liquid in rendering the earths and alkalies mild. 'Such was the state of pneumatic chemistry when Mr. Cavendish began these experimental researches.' 'His paper (*Experiments on Air*, *Phil Trans.* 1784, p. 119), contains an account of two of the greatest discoveries in chemistry that have ever yet been made public—the composition of water and that of nitric acid,' and in that of 1785 (p. 372), he showed that nearly the whole of the irrespirable part of the atmosphere is convertible into nitric acid, when mixed with oxygen and subjected to the operation of the electric spark." "The last words that he uttered were characteristic of an unalterable love of method and subordination; he had ordered his servant to leave him, and not to return until a certain hour, intending to pass his latest moments in the tranquillity of perfect solitude; but the servant's impatience to watch his master diligently having induced him to infringe the order, he was severely reproved for his indiscretion, and took care not to repeat the offence until the scene was finally closed." (The last quotation is from *Works of Thomas Young*, Vol. II., 1855.)

We shall have occasion later on to refer to other work of this eccentric nobleman that is of interest to the physiologist, viz., an account of his *Attempts to imitate the Effects of the Torpedo* (1776). Most of these extracts are taken from the *Life of Cavendish* (1851, Cavendish Society) by one of the noblest of nature's noblemen, viz., George Wilson M.D., then Lecturer on Chemistry, Edinburgh.

Nitrogen was discovered in 1772 by Rutherford, who found that the irrespirable part of air, when treated with lime, still leaves another gas. This gas we now call nitrogen, although Rutherford did not give it that name. Lavoisier ascertained its properties, and preferred to call it "azote," because it did not support life. Now we know this gas as nitrogen—so called from its connection with nitre. Azote, however, forms an integral part of every proteid and proteid-like body—of the "physical basis of life" itself.

JOSEPH PRIESTLEY.

1733-1804.

BORN in 1733 at Fieldhouse, near Leeds, he died in the far-off Northumberland Town in Pennsylvania, on the banks of the Susquehannah, about 120 miles from Philadelphia. Strange and eventful history. A tractarian on religious subjects; an assistant parson in a small meeting-house in Needham Market, Suffolk—income £30 a year; Unitarian minister in a meeting-house in Nantwich in Cheshire (1758), where he kept a school, and taught privately, writing at this time his grammar and more tracts.

In 1761 he succeeded that erudite and wandering scholar, Dr. J. Aiken, as teacher of languages in the Dissenting academy at Warrington, where he remained for six years, and where he wrote his *History of Electricity,* aided by the friendly help of Franklin in respect of books—a work which first brought him into notice amongst scientific men. He became a Fellow of the Royal Society in 1766. In 1767 he returned to Leeds, where he began his studies in pneumatic chemistry, incited thereto "by living in the immediate vicinity of a brewery." It would seem that the "latitude" of his views determined the Board of Longitude in their decision—prompted perhaps thereto by certain ecclesiastics—not to acquiesce in an arrangement whereby it was agreed he should accompany Captain Cook on his second voyage. Another change, and then he moved to Birmingham.

Theology and politics for a time engaged his attention. The French Revolution was in progress, Priestley's political opinions led to this result, that, in a riot in 1791, "his house was burned down, and he narrowly escaped with his life." He fled to London and ultimately set out for America, where he died in 1804.

Priestley's experiments on respiration begin with air infected by animal respiration, and his attempts to restore it to a state of purity. Here is the story in Priestley's own words :—

"*Experiments and Observations on Different Kinds of Air*, by Joseph Priestley, LL.D., F.R.S.—Of the restoration of air in which a candle has burned out, by vegetation.

"It is well known that a flame cannot subsist long without change of air, so that the common air is necessary to it, except in the case of substances into the composition of which nitre enters; for these will burn *in vacuo,* in fixed air, and even under water, as is evident in some rockets, which are made for this purpose. It is generally said, that an ordinary candle consumes, as it is called, about a gallon in a minute. Considering this amazing consumption of air, by fires of all kinds, volcanoes, &c., it becomes a great object of philosophical inquiry, to ascertain what change is made in the constitution of the air by flame, and to discover what provision there is in nature for remedying the injury which the atmosphere receives by this means.

"Though this experiment failed, I have been so happy, as by accident to have hit upon a method of restoring air, which has been injured by the burning of candles, and to have discovered at least one of the restoratives which nature employs for this purpose. It is vegetation. This restoration of vitiated air, I conjecture, is effected by plants imbibing the phlogistic matter with which it is overloaded by the burning of inflammable bodies. But whether there be any foundation for this conjecture or not, the fact is, I think, indisputable. I shall introduce the account of my experiments on this subject, by reciting some of the observations which I made on the growing of plants in confined air, which led to this discovery."

"One might have imagined that, since common air is necessary to vegetable as well as animal life, both plants and animals had affected it in the same manner, and I own I had that expectation when I first put a sprig of mint into a glass jar, standing inverted in a vessel of water; but when it had continued growing for some months, I found that the air would neither extinguish a candle, nor was it at all inconvenient to a mouse which I put in. The plant was not affected any otherwise than was the necessary consequence of its confined situation, for plants growing in several other kinds of air were all affected in the very same manner."

"Finding that candles would burn very well in air in which plants had grown a long time, and having had some reason to think that there was something attending vegetation which restored air that had been injured by respiration, I thought it was possible that the same process might also restore the air that had been injured by the burning of candles. Accordingly, on the 17th of August, 1771, I put a sprig of mint into a quantity of air in which a wax candle had burned out, and found that, on the 27th of the same month, another candle burned perfectly well in it. This experiment I repeated, without the least variation in the event, not less than eight or ten times in the remainder of the summer.

"This restoration of air, I found, depended upon the vegetating state of the plant; for though I kept a great number of the fresh leaves of mint in a small quantity of air in which candles had burned out, and changed them frequently for a long space of time, I could perceive no melioration in the state of the air.

"This remarkable effect does not depend upon anything peculiar to mint, which was the plant that I always made use of till July, 1772, for on the 16th of that month I found a quantity of this kind of air to be perfectly restored by sprigs of balm, which had grown in it from the 7th of the same month."

We need not recount his experiments on "dephlogisticated air"—what we now know as oxygen. He had, indeed, prepared that gas, and knew many of its properties, but failed to recognise its true meaning, so dominated were his conceptions by the phlogistic theory. We may, however, in these days of inhalation of oxygen, record Priestley's own observations on this subject:—

"It may hence be inferred that a quantity of very pure air would agreeably qualify the noxious air of a room in which much company should be confined, and which should be so situated that it could not be conveniently ventilated, so that, from being offensive and unwholesome, it would almost instantly become sweet and wholesome. This air might be brought into the room in casks, or a laboratory might be constructed for generating the air, and throwing it into the room as fast as it could be produced. This pure air would be sufficient for the purpose of many assemblies, and a very little ingenuity would be sufficient to reduce the scheme into practice.

"From the great strength and vivacity of the flame of a candle in this pure air, it may be conjectured that it might be peculiarly salutary to the lungs in certain morbid cases, when the common air would not be sufficient to carry off the phlogistic putrid effluvium fast enough. But, perhaps, we may also infer from these experiments that, though pure dephlogisticated air might be very useful as a medicine, it might not be so very proper for us in the usual healthy state of the body; for, as a candle burns out much faster in dephlogisticated than in common air, so we might, as may be said, live out too fast, and the animal powers be too soon exhausted in this pure kind of air. A moralist, at least, may say that the air which nature has provided for us is as good as we deserve. My reader will not wonder that, after having ascertained the superior goodness of dephlogisticated air, by mice living in it and the tests above-mentioned, I should have the curiosity to taste it myself. I have gratified that curiosity by breathing it, drawing it through a glass syphon, and by this means I reduced a large jar full of it to the standard of common air. The feeling of it to my lungs was not sensibly different from that of common air, but I fancied that my breast felt peculiarly light and easy for some time afterwards. Who can tell but that, in time, this pure air may become a fashionable article in luxury? Hitherto, only two mice and myself have had the privilege of breathing it."

There is another historical investigation of Priestley's, and a very practical—at least extensively used—application thereof that may be recorded as of interest both to physiologists and medical men, viz., his *Directions for impregnating Water with Fixed Air* (1772). It may be interesting to have in Priestley's own words his account of this matter—obviously, the idea of the original manufacture was purely altruistic—the benefit of the health of sailors :—

"It was a little after midsummer, 1767, that I removed from Warrington to Leeds; and living, for the first year, in a house that was contiguous to a large common brewery, so good an opportunity produced in me an inclination to make some experiments on the fixed air, that was constantly produced in it. One of the first things I did in this brewery was to place shallow vessels of water within the region of fixed air, on the surface of the fermenting vessels; and having left them all night, I generally found, the next morning, that the water had acquired a very sensible and pleasant impregnation; and it was with peculiar satisfaction that I first drank of this water, which, I believe was the first of its kind that had ever been tasted by man.

"Several of my friends who visited me while I lived in that house will remember my taking them into that brewery, and giving them a glass of this Pyrmont water made in their presence.

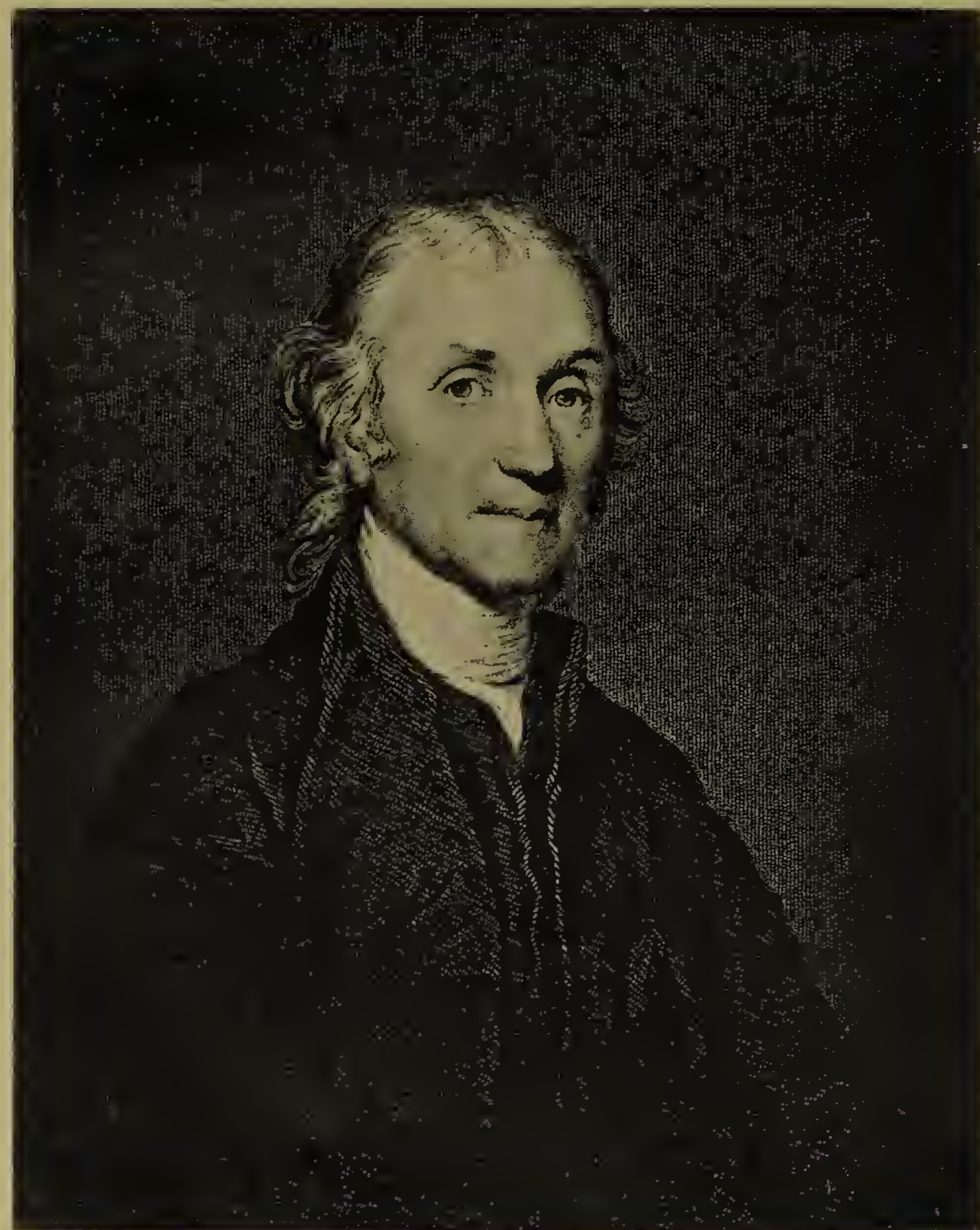
"From 1767 to 1772, I never heard of any method of impregnating water with fixed air but that above mentioned. Being at dinner with the Duke of Northumberland in the spring of the year last-mentioned, his Grace produced a bottle of water distilled by Dr. Irving, for the use of the navy. This water was perfectly sweet, but, like all distilled water, wanted the briskness and spirit of fresh spring water; when it immediately occurred to me, that I could easily mend that water for the use of the navy, and perhaps supply them with an easy and cheap method of preventing or curing the sea scurvy, viz., by impregnating it with fixed air. For, having been busy about a year before, with my experiments on air, in the course of which I had ascertained the proportional quantity of several kinds of air, that given quantities of water could take up, I was at no loss for the method of doing it in general, viz., inverting a jar filled with water, and conveying air into it, from bladders previously filled with air. This scheme I immediately mentioned to the Duke and the company, who all expressed their wishes that I would attend to it, and endeavour to reduce it into practice; which I promised to do.

"A few days after this, having occasion to wait on Sir George Savile, I carried with me a bottle of my impregnated water, and told him the use that might be made of it, viz., that of supplying a pleasant and wholesome beverage for seamen, and such as might probably prevent or cure the sea scurvy. Sir George, with that warmth with which he espouses everything that he conceives to be for the public good, insisted upon writing a card immediately to Lord Sandwich, proposing me to introduce me to him as having a proposal for the use of the navy. As I could make no objection, the card was accordingly written, and an answer was presently returned by his Lordship informing us, that he would be glad to see us the next day."

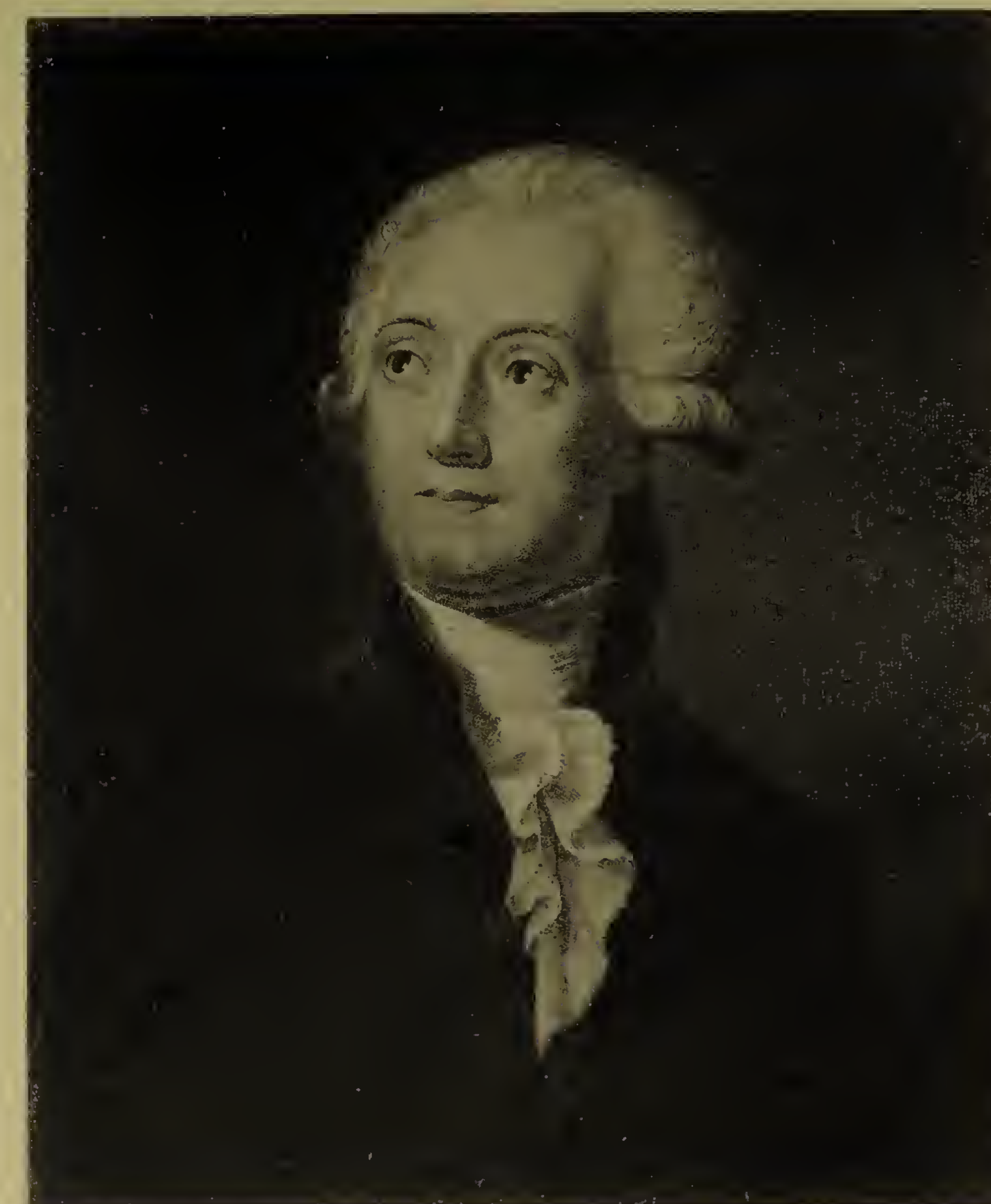
ANTOINE L. LAVOISIER.

1743–1794.

OF all the crimes committed during the Reign of Terror, there is none so atrocious, or that lies so heavily on the national conscience, as the execution of Antoine Laurent Lavoisier on the morning of May 9th, 1794.



J. PRIESTLEY.



LAVOISIER.

"Is it then true, that the exercise of all the social virtues, the rendering of important services to one's country, a career usefully employed for advancing the progress of the arts and extending the boundaries of human knowledge, do not suffice to preserve one from a sinister end, and to avoid perishing on the scaffold like a culprit?"

These are the words written by Lavoisier a few days before his execution.

There was born at Paris on August 26th, 1743, one who made the name of Lavoisier immortal. He was educated at first for the law, but soon natural science attracted him, and he studied botany under B. de Jussieu and chemistry under Rouell. Like another of his compatriots—Cl. Bernard—and many men of science, he composed a drama. He was admitted to the Academy of Sciences on June 1st, 1768 (æt. 25). He married in 1771, and all went well until there came with awful suddenness his tragic end. We pass over here his connection with *Le Ferme Général*, and all that this connection meant to him. How strange are the events of history! Madame Lavoisier in 1805 married Benjamin Thompson, better known as Count Rumford (died 1814), but after four years "de luttes et de récriminations, une séparation à l'aimable eut lieu en 1809." Madame Lavoisier herself died in 1836, æt. 78.

[E]RRATUM.

PAGE 71.

"Le Ferme Général" should read "La Ferme Générale."

Priestley was a slave to the phlogistic theory. Lavoisier in 1775 published his fundamental paper *On the nature of the Principle which combines with Metals during Calcination.* He found that a metal took up something—in fact, gained weight—a fact which had been recorded by Mayow long ago. The converse was true: a metallic oxide, in becoming a metal, gave up something to the air. He had, in fact, discovered oxygen, and thus became the creator of modern chemistry. Priestley had prepared "dephlogisticated air" in 1754, and in 1777 Lavoisier called this air respirable air, "vital air," or "acidifying principle" or in its Greek form "oxygène." On May 3rd, 1777, he published his *Experiments on the Respiration of Animals and the changes which take place in the air passing through their lung,* and two other papers on the same subject with Seguin in 1789 and 1790. We need not pursue the matter here; it is known to all. Lavoisier may also be said to have founded thermo-chemistry and calorimetry. With De Laplace in 1780, he published his famous memoir *Sur la Chaleur.* Respiration was a combustion, but not of carbon only, for in his paper on "changes of the air during respiration," *Altérations qu'éprouve l'air respiré* (read at Soc. de Méd. in 1785 and not at the Academy)—containing an exact determination of the amount of oxygen which disappears and carbon dioxide expired, he found that all the oxygen which disappeared was not replaced by carbonic acid. We have already referred to this diminution in the volume of expired air, when speaking of the work of Mayow. How the combination of oxygen with the carbon on the one hand and the

hydrogen on the other took place was not known until Spallanzani experimented, and published his classical *Memoirs on Respiration* (1803), a work edited posthumously "from the unpublished manuscripts of the author" by his friend John Senebier. To the English translation, there is prefixed *A sketch of the life and Writings of Spallanzani*, from which I have taken certain facts. The Letter, conformably to the spirit of the times, is addressed to Citizen Senebier. Every science student of physiology should read and inwardly digest these classical Memoirs of Spallanzani. The plan adopted is to use different animals, beginning with the lowest class and proceeding to the highest. Spallanzani grasped the importance of the New Chemistry.

"Different kinds of 'worms' enclosed in atmospheric air, with or without lungs, all alike absorbed the whole of the oxygen," and carbonic acid was produced. "Worms" confined in pure azote or pure hydrogen equally yielded carbonic acid. "Larvæ weighing only a few grains absorbed in a given time nearly as much oxygen as an amphibious animal infinitely larger." "The stomach, liver, intestines, ovaries of fishes, etc., after they have been separated from the body of the animal," absorb all the oxygen, and give off carbonic acid. "After destruction of the lungs of amphibia, these animals did likewise."

Here then was a mighty stride forward : oxydation does not take place in the lungs, nor, indeed, in the blood. It is the tissues that respire, *i.e.* consume oxygen and give off carbonic acid. Spallanzani had studied profoundly what we now call "internal respiration." Secondly, it is not the oxygen taken in on which the tissues live, and give out carbonic acid, for snails and "worms" give off this gas in an atmosphere of pure azote or hydrogen.

IN this connection we must mention the important treatise of W. F. EDWARDS (born Jamaica, 1777), *On the Influence of Physical Agents on Life*, which first appeared in a French dress, and was translated into English by Dr. Hodgkin and Dr. Fisher (1832). In this work the subject of asphyxia in batrachian reptiles, fishes, and warm-blooded animals, and the influence of temperature and many other subjects are fully discussed. The hypothesis of Dutrochet, some observations on electricity, and Hodgkin's work on absorption and the spleen, and that of his co-worker, Joseph J. Lister, on the microscopic characters of the animal tissues and fluids are added in the English edition. We would have liked to add the portrait of THOMAS HODGKIN (1798–1866) to the list of our Apostles. Hodgkin's thesis on *Absorption*, presented to Edinburgh University (1823), is particularly interesting. It contains an admirable historical account of the lymphatic system and the absorption from the intestinal tract of colour fluids, &c. After joining the College of Physicians he became Curator of the Museum of Guy's Hospital.

Disappointed as regards the result of an election, he transferred his services to St. Thomas's Hospital (1837). He was a follower of Bichat, and taught the importance of changes in the tissues as a fundamental factor in pathology. He wrote much, and had great literary ability. His *Essay on Medical Education* (1828) is well worth reading. His chief work is *Lectures on the Anatomy of Serous and Mucous Membranes* (1836–37), in which he shows the great value of morbid anatomy, a subject which in these days seems to be largely pushed aside by an aspiring younger and prolific sister. Be this as it may, Hodgkin has left his impress on pathology, and any one who wishes to read the record of a noble life will find such in Sir Samuel Wilks' account of Hodgkin in *Guy's Hospital Reports*, XXIII. (1878). Hodgkin resigned practice, travelled much, and died of dysentery in Jaffa. As showing the influence of the teaching, or rather the success, of a method, let me quote his remarks on the well-known episode—a striking one—in the early career of Bichat at the Hôtel-Dieu.

"The practice of taking notes is the most powerful means of counteracting this inconvenience, and is, I am persuaded, by many pupils, diligently and effectually followed up. Still I could wish that the regulations of our schools did not wholly leave this important point to the discretion of the pupil. It was the practice of Desault to require of those who attended his visits at the Hôtel-Dieu narratives of the principal cases, which were publicly read. Attention and emulation were unavoidably excited, and I need adduce no further proof of its utility than the example of Bichat, whose splendid talents were first brought into view on some of these occasions." (Hodgkin's *Essay on Med. Education*, Lond. 1828.)

"Edwards's book was published in 1832, and amongst other subjects are some very interesting observations on the effects of heat on animal life. Experiments on frogs showed that death took place at the normal temperature of warm-blooded animals. He speaks of instances of persons going into hot ovens with impunity, and their temperature not rising; and if the experiments were made with animals the result was the same, but if their temperature rose they died. He therefore came to the conclusion that an animal could not sustain life beyond a temperature of 120°. He alludes to an observation made by the celebrated Franklin, to the effect that, although he one day in summer found the temperature of the air was 100°, that of his own body was only 96°, proving for him that warm-blooded animals have the power of maintaining in themselves a temperature inferior to that of the atmosphere, when the latter is above its ordinary limits, and that notwithstanding the changes of climate and seasons the temperature of the body is permanent. In reference, Edwards says, 'When Franklin had made experiments on the power of evaporation in the cooling of liquids he referred to the same cause the faculty which he attributed to animals of maintaining the temperature of their own bodies below that of the air when its heat is excessive,' and he also alludes to experiments made by Dr. Fordyce, proving that heat is given off by transudation through the skin, and adds, 'Evaporation is also sufficient to retain the temperature of animals and in organized bodies below that of the external air, when the latter is excessive, that is, when it is above the body temperature of warm-blooded animals.' He then speaks of the elevation of temperature in disease, and quotes a case of Dr. Prevost, of Geneva, where a boy with tetanus had a temperature of 110·75°, and remarks, 'It will be admitted that it is important to moderate the excess of heat, not

only in such extreme cases, but in others in which it is not so high, whether it proceeds from without or within. Often the excessive production of heat has no salutary tendency, when it is necessarily still more important to moderate it. The most powerful means furnished by external agents consists in the application of water of a suitable temperature. It is evident that this reduces the temperature of the body. He explains the advantages which have frequently been derived from the use of cold water under the varied forms of baths, douches, and affusions, in cases of the extraordinary development of heat.' Dr. Hodgkin comments on this, and goes on to say, 'In conjunction with the researches of Dr. Currie, of Liverpool, they will afford the most valuable assistance in the regulation of clothing, of exposure to open air, of confinement within doors, and of the application of the various forms of baths.'" (S. Wilks, *Guy's Hospital Reports*, 1878.)

Returning to the subject of the respiratory processes in the lungs and in the tissues, further progress was not possible until there were new methods. This came when it was possible to extract the gases of the blood and tissues, and to measure their respective amounts and relations in arterial and venous blood and other fluids. Mayow knew that blood gave off gases to a vacuum (1670). Humphry Davy, in 1799, obtained the blood gases by heating the blood, but before this Priestley had obtained carbonic acid from blood by passing through it another gas, a method used much later by Bernard (1857), only he used carbonic oxide. With the invention of the mercurial gas pump, and the extraction of the blood gases by means of it, a new chapter in modern physiology began. Gustav Magnus in 1837 (Poggendorff's *Ann.* 40, p. 594) was thus able to analyse the gases of arterial blood. At once, the names of Ludwig, Pflüger, and their pupils, Bunsen, Lothar Meyer, Regnault and Reiset, P. Bert, L. Hermann, and many more occur to one. With this subject are closely linked the discoveries in the chemistry of the blood—its hæmoglobin and the remarkable properties of this pigment, with which the names of Sir George Gabriel Stokes (*Proc. Roy. Soc.*, 1846), Hoppe-Seyler (1825–1895), W. Preyer (1841–1897), and many others, are associated. All of which is part of modern physiology, and here I leave the subject.

One would like also to write the story of the coagulation of the blood—connected with the names of Wm. Hewson, Denis, Andrew Buchanan, Alex. Schmidt, &c.—but at the moment this is impossible. We must, however, refer to some problems in connection with the circulation of the blood, in the solution of which our own countrymen have led the way and furnished methods not only for physiology, but also for all cognate sciences.

STEPHEN HALES.

1677-1761.

MEDICINE owes much to the sons of the Church. Stephen Hales was not a medical man, nor had he the advantage of a medical education. Born the son of a baronet, in 1677, at Bekesbourne, in Kent, he was educated at Cambridge, and describes himself in his famous *Statical Essays* as Rector of Farringdon, Hampshire, and Minister of Teddington, Middlesex. In the original picture from which our collotype is taken, he is described as "Clark of the Closet to her Royal Highness the Princess Dowager of Wales," D.D., F.R.S. (æt. 82).

All through life he kept experimenting on a great variety of subjects. The records are most carefully kept and every detail entered. He worked chiefly at Teddington. He wrote an *Essay Against the Use of Spirits*—and was thus an advocate of temperance principles—and others on *Freshening Sea Water*, and *Preserving Meat* during long sea voyages. He invented a "ventilator" for purifying the air of ships, and thus became a pioneer in sanitary reform. He was an F.R.S., and the Royal Society published his *Statical Essays*.

Volume one, which contains his *Vegetable Staticks* on the sap in vegetables, also a *Specimen of an Attempt to Analyse the Air by a Great Variety of Chymico-Statical Experiments*, was published (1726–27).

Volume two—1733—contains *Hœmastatics*. This deals with the hæmodynamics of the circulation. He was the first to determine, by experiment on a living animal, the exact pressure of the blood on the blood-vessels. Previously he had determined the pressure of the ascent of the sap in the vine and many other interesting phenomena.

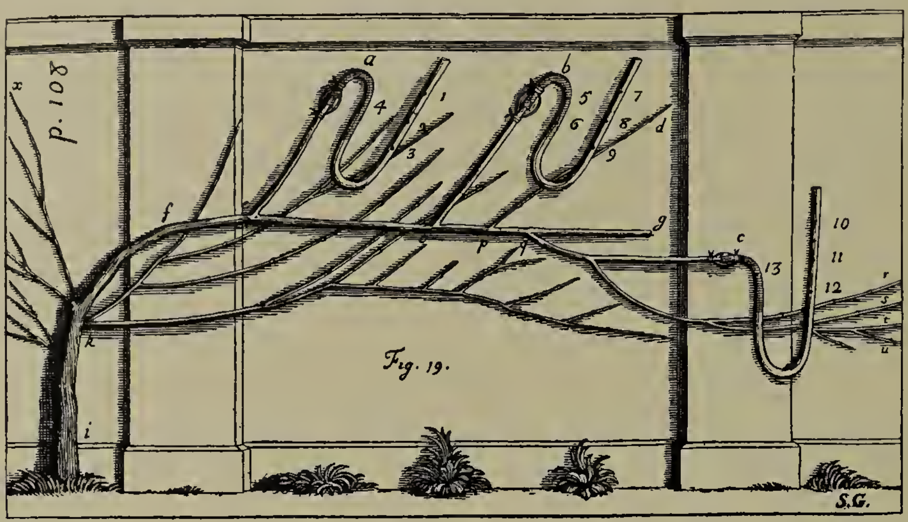
"VEGETABLE STATICKS."—Experiment XXXVII.

"April 4th, I fixed three mercurial gages (Fig. 19) *a*, *b*, *c*, to a vine, on a south-east aspect, which was 50 feet long, from the root to the end *ru*. The top of the wall was $11 + \frac{1}{2}$ feet high; from *i* to *k*, 8 feet; from *k* to *e*, 6 feet $+ \frac{1}{2}$; from *e* to *a*, 1 foot + 10 inches; from *e* to *o*, 7 feet; from *o* to *b*, $5 + \frac{1}{2}$ feet; from *o* to *c*, 22 feet 9 inches; from *o* to *u*, 32 feet 9 inches. The branches to which *a* and *c* were fixed were thriving shoots two years old, but the branch *ob* was much older.

"When I first fixed them, the mercury was pushed by the force of the sap, in all the gages down the legs 4, 5, 13, so as to rise nine inches higher in the other legs.

"The next morning at 7 a.m. the mercury in *a* was pushed $14 + \frac{1}{4}$ inches high, in *b* $12 + \frac{1}{4}$, in *c* $13 + \frac{1}{2}$. The greatest height to which they pushed the sap severally was, *a* 21 inches, *b* 26 inches, *c* 26 inches. The mercury constantly subsided by the retreat of the sap about 9 or 10 in the morning, when the sun grew hot; but in a very moist foggy morning the sap was later before it retreated, viz., till noon, or some time after the fog was gone.

"About 4 or 5 o'clock in the afternoon; when the sun went off the vine, the sap began to push afresh into the gages, so as to make the mercury rise in the open legs; but it always rose fastest from sun-rise till 9 or 10 in the morning.



HALES'S METHOD OF MEASURING THE FORCE OF THE ASCENT OF THE SAP IN THE VINE.

"The sap in *b* (the oldest stem) played the most freely to and fro, and was therefore soonest affected with the changes from hot to cool, or from wet to dry, and *vice versâ*.

"And April 20, towards the end of the bleeding season, *b* began first to suck up the mercury from 6 to 5, so as to be 4 inches higher in that leg than the other. But April 24, after a night's rain, *b* pushed the mercury 4 inches up the other leg, *a* did not begin to suck till April 29, viz., 9 days after *b*; *c* did not begin to suck till May 3, viz., 13 days after *b*, and 4 days after *a*. May 5th at 7 a.m. *a* pushed 1 inch, *c* $1 + \frac{1}{2}$, but towards noon they all three sucked. I have frequently observed the same difference in other vines, where the like gages have been fixed at the same time, to old and young branches of the same vine, viz., the oldest began first to suck.

"In this experiment we see the great force of the sap, at 44 feet 3 inches distance from the root, equal to the force of a column of water 30 feet + 11 inches + $\frac{3}{4}$ high.

"From this experiment we see, too, that this force is not from the root only, but must also proceed from some power, in the stem and branches: For the branch *b* was much sooner influenced by changes from warm to cool, or dry to wet, and *vice versâ*, than the other two branches *a* or *c*; and *b* was in an imbibing state, 9 days before *a*, which was all that time in a state of pushing sap; and *c* pushed 13 days after *b* had ceased pushing, and was in an imbibing state. Which imbibing state vines and apple-trees continue in all the summer, in every branch, as I have found by fixing the like gages to them in July."

Hales's method of placing a vertical tube in an artery is still the most striking method of bringing home some of the facts of blood pressure to students. His experiments mark a great and specific advance in this subject and carry one on from Borelli to Poiseuille and Ludwig, who used a mercury manometer instead of a long straight tube—lead us, in fact, to the kymograph of Ludwig, and, indeed, indirectly to the graphic method as now used in physiology.

"AN ACCOUNT OF SOME HYDRAULICK AND HYDROSTATICAL EXPERIMENTS MADE ON THE BLOOD AND BLOOD-VESSELS OF ANIMALS."—EXPERIMENT I.

"In December I caused a mare to be tied down alive on her back; she was fourteen hands high, and about fourteen years of age, had a fistula on her withers, was neither

very lean nor yet lusty. Having laid open the left crural artery about three inches from her belly, I inserted into it a brass pipe whose bore was one-sixth of an inch in diameter; and to that, by means of another brass pipe which was fitly adapted to it, I fixed a glass tube, of nearly the same diameter, which was nine feet in length: then untying the ligature on the artery, the blood rose in the tube eight feet three inches perpendicular above the level of the left ventricle of the heart: but it did not attain to its full height at once; it rushed up about half way in an instant, and afterwards gradually at each pulse twelve, eight, six, four, two, and sometimes one inch.

"When it was at its full height, it would rise and fall at and after each pulse two, three, or four inches; and sometimes it would fall twelve or fourteen inches, and have there for a time the same vibrations up and down at and after each pulse, as it had when it was at its full height; to which it would rise again, after forty or fifty pulses."

"Hales also observed that the blood rose in the temporal artery of a sheep 6½ feet, carotid of dog 4–6 feet; while in the jugular vein of a horse it rises only from 12 to 21 inches, and in dogs 4–8½ inches."

X. BICHAT.

1771-1802 (æt. 31).

THE region of the Jura has given to French science many sons, and not the least renowned of those who have exercised a profound influence on its progress are Marie François Xavier Bichat and L. Pasteur. Bichat was born at Thoirette. He studied at Montpellier and Lyons, but owing to the vicissitudes of war he next came to Paris, where he made the acquaintance of, and became assistant to, the famous surgeon Desault, whose works he edited (1791–93). Desault died suddenly in 1795. In 1797, he began to teach anatomy, surgery, physiology, and soon had a large audience. He also became physician to the Hôtel-Dieu, where he made in one year over six hundred post-mortem examinations. A plaque in the vestibule of the main entrance of the New Hospital commemorates Bichat's connection with this famous hospital, and a statue—the only one in the quadrangle of the old École de Médecine in Paris, serves to attest the high honour in which the name and fame of Bichat are held.

In 1800 he published his treatise on *Membranes*, and treated of them as: Simple—(1) Mucous, (2) Serous, (3) Fibrous. Compound—(1) Sero-fibrous, (2) Sero-mucous, (3) Fibro-mucous (the arachnoid and synovial membranes were "accidental"); and his still more famous *Sur la Vie et sur la Mort*. His *Anatomie Générale* appeared in 1801. He died a year afterwards, in 1802.

From the physiological side he spoke of functions of "animal life" as distinct from those of "organic life," a doctrine of the Montpellier School, but undoubtedly his advocacy gave currency to these views, which were fully set forth in his treatise *On Life and Death* (1799). Perhaps Bichat owes something of his classification of tissues

to his master, the famous Pinel, who taught that disease consisted in an alteration in the tissue of an organ; and, in his turn, Pinel profited from the work of Bichat. His work falls in direct line with that of Haller. Sensibility and contractibility play their part. How strange is his definition of life—not life, but death stands in the forefront. *La vie est l'ensemble des fonctions qui résistent à la mort.* "Life is the sum total of the forces that resist death." His great work on *Anatomy* and his other works seem to have obtained greater recognition from the physicians than from the anatomists. Bichat is regarded as the founder of General Anatomy, although he did not use a microscope. In his famous work, in Section VI. "Remarks on the Organization of Animals," he sets forth his doctrine of tissues:—

"All animals are compounded of various organs, each of which, exercising a separate function, and in a manner peculiar to itself, concurs to the preservation of the whole. These organs are so many distinct and collateral machines, subordinate to the great and general machine. Each individual machine accordingly is itself composed of several tissues differing in nature, and constituting the real elements of these organs. Chemistry has its simple bodies, which, by various combinations they admit of, form the compound ones; these are caloric, light, hydrogen, oxygen, &c. Anatomy, in like manner, has its simple tissues, which, by their combinations, form the organs properly so called. These tissues are (1) The cellular membrane, (2) The nerves of animal life, (3) The nerves of organic life, (4) The arteries, &c., and so on, in all 21, the last being the cutis."

"That any one should have accomplished so much, and of such a nature, so original, so vast, so practical, and, it may be added, so perfect, in such a short period of existence, is only to be attributed to the possession of genius, accompanied by the most patient and indefatigable industry." "Bichat fell a victim to his zeal for science and his profession, and died in the height of his prosperity and reputation. No one was ever more sincerely mourned; his loss was a national one, and such it was felt to be. Corvisart communicated the intelligence of the death of Bichat to the First Consul, Napoleon, in the following words:—'Bichat vient de mourir sur un champ de bataille qui compte aussi plus d'une victime; personne en si peu de temps n'a fait tant de choses et aussi bien.'" (T. J. Pettigrew.)

The portrait here given of Bichat does not bring out the remarkable asymmetry of his head, the left side being much more prominent. (Cloquet, *Traité d'Anatomie,* I., pl. xxix.)

THOMAS YOUNG.

1773–1829.

IT is from the life of Young by the Dean of Ely, George Peacock, D.D. (1855), that the following account is mainly taken, and the collotype is, by permission of Mr. A. H. Hallam Murray, copied from Young's portrait in that work. The original was painted by Sir Thomas Lawrence. T. Young was born of Quaker parents, at

Milverton in Somersetshire, and was the eldest of ten children. In his school days he manifested great powers of application and memory; even then his linguistic acquirements were something extraordinary; and a little later, besides the humanities, he had acquired a knowledge of Hebrew, Persian, and Arabic. It was his uncle, Dr. Brocklesby, who directed his attention to medicine. In London, he joined the Windmill School, where he attended the lectures of Matthew Baillie, and Cruickshank those of John Hunter, perhaps, read by E. Home—at any rate in 1793 the year in which Hunter died. Later on he joined St. Bartholomew's Hospital. In 1794 he went to Edinburgh, where at that time Black—already somewhat infirm—Monro (II.) and Gregory were his teachers. To the town of Heine and Haller, to Göttingen, in 1795, where he heard the lectures of Blumenbach, and took his degree of M.D. At the end of his Dissertation, to fill up some blank pages, he gave—

"An alphabet of forty-seven letters designed to express, by their combination, every sound which the organs of the human voice are capable of forming, and thus adaptable as an alphabet for all languages. . . . . It is evident, from reference to it in his correspondence, that this subject was much in his thoughts; and he assures us that it was in connection with inquiries upon the powers of vocalization of the organs of the human voice, and in order to form a perfect conception of what a sound was, that he was conducted through a series of experiments and observations on the theory of the formation of sound and the laws of its propagation, to the consideration of analogous propositions respecting the theory of light, which became the foundation of his greatest discovery." (Peacock's *Life*, p. 90.)

At his examen he had as co-students Niemeyer and the famous Treviranus. It might be well to take a glimpse at a not too distant past, as to the conduct of examinations in Göttingen.

"I made," says he, "no preparatory study, as is usual here and also at Edinburgh not uncommon under the name of grinding. The examination lasted between four and five hours; the four examiners were seated round a table, well furnished with cakes, sweetmeats, and wine, which helped to pass the time agreeably; the questions were well calculated to sound the depth of a student's knowledge in practical physic, surgery, anatomy, chemistry, materia medica, and physiology; but the professors were not very severe in exacting accurate answers. Most of them were pleased to express their approbation of my replies. We were all previously obliged to give a summary account of the manner in which our lives had been spent.

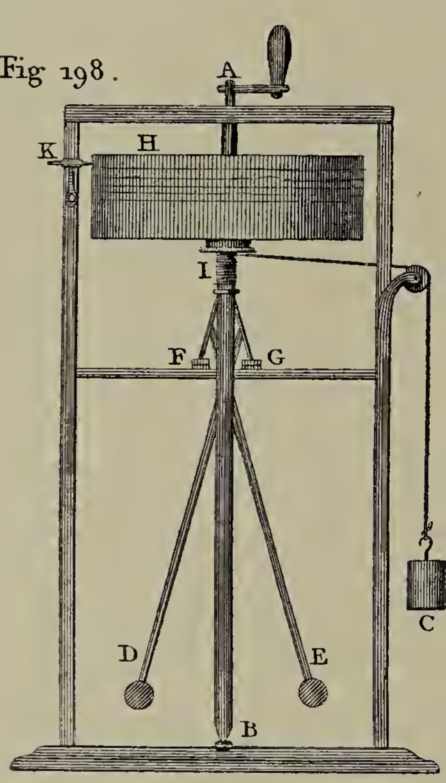
"The *lectio cursoria* on the human voice was given in the auditorium. He disputed according to the forms; was complimented on his performance, and after reading something like a prayer, Young was married to Hygiea, and created Doctor of Physic, Surgery, and Man-midwifery."

He returned to England in 1797, took a house in Welbeck Street, and commenced practice. Owing to the laws then in force, in order to become a Fellow of the College of Physicians, he had to keep terms at either Oxford or Cambridge to enable him to obtain the degree of one of these Universities, and by means of this instrument (Cambridge, 1803, æt. 30), he was enabled to join the College of Physicians.

In 1802 he was appointed Professor of Natural and Experimental Philosophy at the Royal Institution. It is in the syllabus of these lectures that there occurs the first publication of his most famous discovery, the law of the interference of light, " one of the greatest discoveries since the time of Newton, and which has subsequently changed the whole face of optical science." Indeed, this discovery exerted a profound influence on the rival theories of light—undulatory *versus* the Newtonian hypothesis. The volumes published in 1807, *A Course of Lectures on Natural Philosophy*, and *The Mechanical Arts* in Lecture XVII. " On Timekeepers " (Kelland's ed., p. 146, 1845), contain the following passage. This marks the beginning of the graphic method.

" A chronometer may be constructed on this principle for measuring small portions of time which appears to be capable of greater accuracy than Mr. Whitehurst's apparatus, and by means of which an interval of a thousandth part of a second may possibly be rendered sensible. If two revolving pendulums be connected with a vertical axis, in such a manner as to move two weights backwards and forwards according as they fly off to a greater or smaller distance, the weights sliding, during their revolution, on a fixed surface, A, a small increase of velocity will considerably increase the distance of the weight from the axis, and consequently the effect of their friction, so that the machine will be immediately retarded, and its motion may thus be made extremely regular. It may be turned by a string coiled round the upper part, and this string may serve as a support to a barrel, sliding on a square part of the axis, which will consequently descend as it revolves. Its surface, being smooth, may be covered either with paper or with wax, and a pencil or a point of metal may be pressed against it by a fine spring so as to describe always a spiral line on the barrel, except when the spring is forced a little on one side by touching it slightly, either with the hand, or by means of any body of which the motion is to be examined, whether it be a falling weight, a vibrating cord or rod, or any other moving substance. In this manner, supposing a barrel a foot in circumference to revolve in two seconds, each hundredth of an inch would correspond to the six-hundredth part of a second, and the scale might be still further enlarged if it were necessary. (Plate xv., Fig. 198.) By means of this instrument we may measure, without difficulty, the frequency of the vibrations of sounding bodies, by connecting them with a point, which will describe an undulated path on the roller. These vibrations may also serve in a very simple manner for the measurement of the minutest intervals of time ; for if a body, of which the vibrations are of a certain degree of frequency, be caused to vibrate during the revolution of an axis, and to mark its vibrations on a roller ; the traces will serve as a correct index of the time occupied by any part of a revolution, and the motion of any other body may be very accurately compared with the number of alterations marked in the same time, by the vibrating bodies. For many purposes, the machine, if heavy enough, might be

Fig 198.



YOUNG'S METHOD OF RECORDING MINUTE INTERVALS OF TIME BY MEANS OF A VIBRATING STYLE WRITING ON A REVOLVING CYLINDER.

THOMAS YOUNG.

turned by a handle only, care being taken to keep the balls in a proper position, and it would be convenient to have the descent of the barrel regulated by the action of a screw, and capable of being suspended at pleasure."

We pass over many events in his life, his position as foreign secretary of the Royal Society 1802, a post which he retained until his death, secretary to the Board of Longitude (1818), conductor of the Nautical Almanac, adviser to an Insurance Company (consult *A formula for expressing the Decrement of Human Life*, 1826). Nor must we forget that Young in 1827 was the successor of Volta in the Académie des Sciences at Paris. He died in 1829, æt. 56, a victim to an atheromatous condition of the blood-vessels. And we omit mention of many of his discoveries on sound, light, &c.

In 1808 he became a Fellow of the Royal College of Physicians, Physician to St. George's Hospital 1810. In 1813 he published *An Introduction to Medical Literature*, which included a Nosology. We pass over his "Eriometer" and his measurement of the size of pus cells and blood corpuscles. About 1815 he directed his attention to Hieroglyphics. "His labours in the field of Egyptian literature are the greatest effort of scholarship and ingenuity of which modern literature can boast."

I am incapable of doing justice to the work of Young, in its bearing on physiology or medicine, but we may refer to certain subjects of general interest. The mechanism of accommodation of the eye for near and distant objects early attracted his attention, and he thought he had found that this was accomplished owing to the muscularity of the lens, and strangely enough John Hunter claimed priority of this somewhat remarkable theory. Leeuwenhoek with his universal inquisitiveness had seen the fibres of lens but mistaken their nature. It matters little : Young's idea of the change of the form of the lens was right, his muscularity theory wrong. His paper contains an excellent description of the position of the planes in the lens, and the course of the fibres he thought were muscular. Later he saw that the theory of accommodation which involved a change in the curvature of the cornea was untenable. The true theory was not yet. His great discovery of the law of interference evoked the wrath of the Edinburgh Reviewers, especially Brougham. This also we pass over, but their criticisms made Young unhappy. His theory of colour vision remained largely unnoticed until Helmholtz re-discovered it, and now this theory is known as the Young-Helmholtz theory of colour vision. (See Fr. Arago, *Biograph. of Distinguished Scientific Men*, 1857.)

Thomas Young, scholar, philosopher, linguist, biographer, Egyptologist, reviewer, and discoverer must be regarded as one of the most highly gifted and enlightened men the age has produced, and we are proud to know that medicine claims him as one of her most

brilliant sons, and as one whose researches in sciences ancillary to medicine have advanced these sciences, and contributed to the progress of physiology and cognate sciences.

Sir CHARLES BELL.

1778-1842.

THE name of Bell is very familiar in the medical history of Edinburgh. Bell was born in Edinburgh—" Scotia's darling seat" — where he took the diploma of the College of Surgeons, assisted his brother John, more especially in illustrating his work on anatomy, for Charles was a most accomplished artist and draughtsman. He was surgeon to the Royal Infirmary in 1799, a post he held until 1806, when a dispute—which we need not refer to here—led him to go to London, at a time when Clive and Abernethy were distinguished lecturers.

Bell joined the famous Windmill School of Medicine, in which the Hunters had achieved fame.

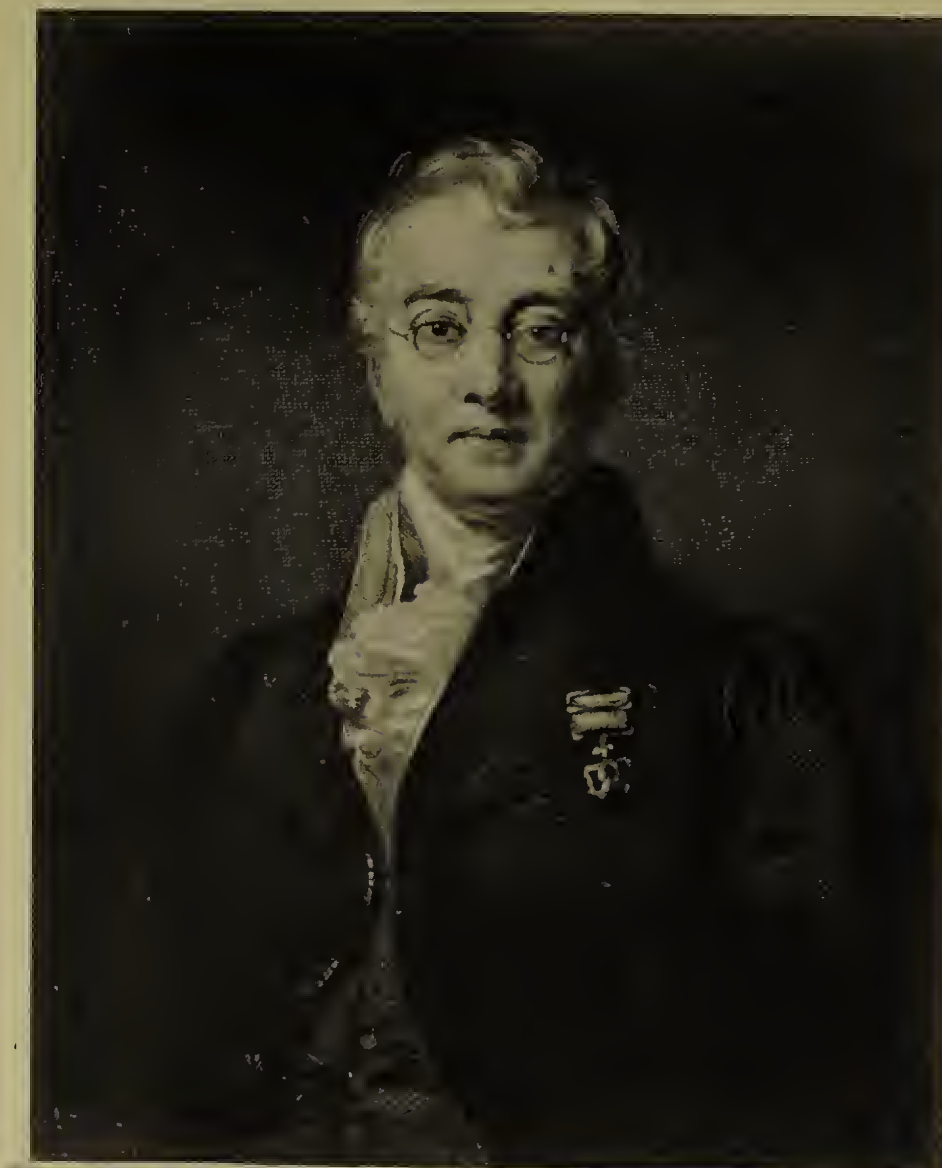
His investigation on respiratory nerves, the effects of section of other nerves, paralysis of the seventh nerve, " Bell's paralysis," the doctrine of the " muscular sense" are part and parcel of modern physiology. Bell was an artist both with pen and pencil. There is a charm about his style of writing, and his artistic powers were such, that had he not become a great surgeon, he had both the ability and the artistic sense to have become a great artist. He wrote one of the *Bridgewater Treatises on the Power, Wisdom, and Goodness of God, as Manifested in Creation—The Hand, its Mechanism and Vital Endowments as Evincing Design.* His artistic powers also found expression in his *Essays on the Anatomy of Expression in Painting* (1806), of which several editions have been published.

In 1812 he was elected surgeon to Middlesex Hospital. He saw military surgery after Corunna (1809), and in Brussels after Waterloo (1815). In 1836 he was invited to accept the Chair of Surgery in Edinburgh University, and he returned to his native city. Leaving aside his work *On the Hand,* and others on similar lines, in support of the theology of Paley, and also his surgical works—the essay in which his name is indelibly associated with the nervous system was published in 1811, privately printed for distribution among his friends, *Idea of a New Anatomy of the Brain.*

" Sir Charles Bell first conceived the ingenious idea that the posterior roots of the spinal nerves, which have upon them a ganglion, are the source of sensation; the anterior roots the source of motion; and that the primitive fibres of these roots after their union are mingled in one trunk, and thus distributed for the supply of the skin and muscles.

X. BICHAT.

MAGENDIE.



SIR CHARLES BELL.

This view he proposed in a treatise entitled *An Idea of a New Anatomy of the Brain, submitted for the Observation of the Author's Friends* (Müller).

"On laying bare the roots of the spinal nerves, I found that I could cut across the posterior fasciculus of nerves, which took its origin from the posterior portion of the spinal marrow, without convulsing the muscles of the back; but that on touching the anterior fasciculus with the point of a knife, the muscles of the back were immediately convulsed." (See *British and Foreign Quarterly Review*, 1840.)

"Recently a discovery has been made which in the history of Physiology ranks second only to the discovery of the circulation of the blood; it is that the nerves which arise by an anterior and a posterior root from the spinal cord derive their power of exciting contractions from the anterior root, and their power of sensation from the posterior root. This discovery is due to Bell. I have since proved that the chemical and galvanic stimuli, applied to the posterior root, have no power of exciting contraction in the muscles to which the spinal nerves are distributed." (Müller's *Physiol.* p. 204, 2nd ed. 1840, trans. by W. Baly.) "Bell, with Müller and Magendie, gave the fundamental distinction between motor and sensory fibres, and showed that the anterior root of a spinal nerve was motor and the posterior sensory, which was confirmed by the strictest experimental evidence by Magendie in 1822."

FRANÇOIS MAGENDIE.

1783–1855.

BORN in the same town as Black—in Bordeaux—in 1783, Magendie inherited from his father a bias towards medicine. He early directed his attention to experimental physiology. His earliest work (1808), was on the functions of the soft palate. From 1816 he became one of the greatest experimental physiologists of his time. He was also physician to La Salpêtrière (1826), and thus his researches deal not only with pure physiology, but also with experimental pathology and toxicology. His name stands out boldly amongst the Professors of the Collège de France, as successor to J. Récamier, 1774–1856, Professor of Physiology and General Pathology. Along with A. Desmoulins, he published *Anatomie des Systèmes nerveux des Animaux à Vertèbres*, with plates, 1825—these plates might with advantage be consulted at the present time—and in 1842, *Phénomènes physiques de la Vie.*

He confirmed by experiment the functions of the anterior and posterior spinal nerve roots (1822), so that not unfrequently Bell's law is spoken of as "Bell-Magendie law." In so doing he discovered the fact of "recurrent sensibility" in connection with the anterior root of a spinal nerve. The exact conditions were determined more exactly by Bernard in 1847.

His *Précis élémentaire de Physiologie* (1816) to my mind represents the embodiment of methodical order in the arrangement of the subject-matter. The doctrine of tissues, however, is still that of Bichat. The experiments on absorption are fundamental.

" That absorption takes place through the veins of a limb was shown by Magendie and Delille. Under opium, they severed all the parts save the artery and vein connecting the leg of a dog with the trunk—the vessels being isolated for a distance of four centimetres, and in one case the artery was replaced by a quill. On injecting Antiar upas into the foot, the symptoms of poisoning set in just as soon as if the limb was in full connection with the trunk." (*Précis*, p. 238, 1816.) J. Hunter tried to show that as regards intestinal absorption, the lymphatics, *i.e.*, the lacteals, were its exclusive agents. (*Medical Commentaries*, V.) Hunter used hot milk placed in the intestine.

" To prove that the rootlets of the portal vein were also concerned in absorption various substances were injected into a loop of intestine of the dog. (1) Rhubarb decoction disappeared from the gut, but none was found in the lymph of the thoracic duct. (2) Prussiate of potash similarly injected was within a quarter of an hour found in the urine, none in the lymph. (3) Dilute alcohol—alcohol pure kills dogs; the blood had an odour of alcohol, the lymph none. (4) The thoracic duct ligatured in the neck; on giving the dog strychnine, it died promptly, as in a normal animal. (5) In a dog with its thoracic duct ligatured, the same poison injected per rectum caused death just as in intact animals. (6) The abdomen of a dog in full digestion was opened, a loop of intestine 4 cm. long ligatured, and all the vessels, lymphatic and vascular, ligatured except a mesenteric artery and vein. One hour after placing nux vomica in the gut, the characteristic symptoms of its action appeared."

The whole subject is very fully treated in his *Phénomènes Physiques de la Vie* (1842), and here we have the precursor of the hypodermic method, viz., the "endermic." A blister is first applied to remove part of the epidermis, and the drug applied to the exposed surface (p. 35). Dame Nature had seen to the hypodermic injection long, long ages ago. The groove in the poison fang of a serpent, the embouchure of the channel under the protection of a sharp penetrative point, is the prototype of the modern hypodermic needle. Still further down in certain invertebrates this principle obtains.

G. Valentin of Berne published in 1867 an important work on a similar subject, *Die physikalische Untersuchung d. Gewebe.*

" Tiedemann and Gmelin, of Heidelberg, have performed numerous experiments with colouring matter and salts which are easily recognised or detected by reagents. [*Versuch über die Wege a. welchen Substanzen a. d. Magen u. Darmkanal ins Blut gelangen*, &c. (1820).] On examining the chyle several hours after colouring matters have been given by the mouth, they have never found it tinged, although the colouring substances were recognised in the blood and urine, and had already passed from the stomach into the intestine. In very numerous experiments it was but a few times only that some portion of the salt taken into the stomach could be detected in the chyle; in a horse to which some sulphate of iron had been given it was detected afterwards in the chyle; and once in a dog which had taken prussiate of potash, this salt was detectable in the chyle, but in a second experiment this was not the case; sulphocyanate of potash given to a dog was also detected in the chyle. The objection, that the substances might be already all absorbed, is not tenable; for the intestine still contained a considerable quantity of them." (Müller's *Phys.*, trans. by Baly.)

J. L. POISEUILLE'S name remains associated with hæmodynamics (1799, Paris–1869). He took his M.D. in Paris in 1828. Three of the four important contributions that bear his name are :—

Sur la force du Cœur Aortique (1828); *Recherches sur les causes du Mouvement du Sang dans les veines* (1830); and in 1839 *Mouv. dans les vaisseaux capillaires.* It is in this quarto work, with four plates, that he figures and describes his *hæmodynamometer*, which is essentially a mercury manometer connected with the interior of an artery by means of a lead tube filled with a solution of carbonate of potash. He watched the oscillations of the mercury in the open limb of the tube. Ludwig added a float, and had the genius to cause this float to write on a recording cylinder, and thus at one *coup* gave us his kymograph, or wave-writer, and the application of the graphic method to physiology. Poiseuille's fourth work, on the flow of fluids in capillary tubes, was published in 1847.

"Influence of respiration on the motion of the blood in the arteries.—Poiseuille perceived, by means of his instrument, what Haller and Magendie had already observed, namely, that the strength of the blood's impulse is increased during expiration; in which act the chest is contracted, and the large vessels in consequence compressed. The column of mercury in his instrument rose somewhat at each expiration, and fell during inspiration. M. Poiseuille found that the rise and fall of the mercury is the same in arteries the distance of which from the heart is different, and that in ordinary tranquil respiration it amounts to from four to ten lines. The increase of the blood's impulse by expiration is in many persons so great, that the pulse at the radial artery becomes imperceptible when inspiration is long continued, and the breath held. This is the case with myself, and in some measure explains the fable of persons possessing the power of altering the action of their hearts at will." (Müller's *Physiol.*, I. p. 221.)

"Poiseuille also measured the degree of dilatation of an artery at each pulse beat. He laid bare the carotid of a horse for about 3 decimetres—12 inches—and inclosed this part of the artery in a tin box, which he filled with water, placing in the upper wall of the box a glass tube. At every pulsation the water rose 70 millimetres and fell again the same distance during each pause. He calculated that the artery was dilated to about $\frac{1}{23}$ of its capacity at each beat."

IN connection with the doctrine of "reflex action" we cannot pass over the name of MARSHALL HALL (1790–1857), who was born near Nottingham—studied at Edinburgh (1809–1812, M.D.). He began practice in Nottingham in 1817, but went to London in 1826, where he practised for seven-and-twenty years with great success. He published various papers on the circulation of the blood and on blood-letting. His chief work, however, is in connection with reflex action, *The Reflex Function of the Medulla Oblongata and Medulla Spinalis* (*Phil. Trans.*, 1833), which attracted the attention of J. Müller and was published in his *Archiv.* His paper on the *True Spinal Marrow and the Excito-motor System of Nerves* was not inserted in the *Transactions.* His *New Memoirs on the Nervous System* were published in 1843. He was an indefatigable worker in many branches, and his name still remains associated with the "Marshall Hall method" of restoring suspended

animation. A most interesting memoir—with a portrait—was published by his widow in 1861.

The following account by Professor C. S. Sherrington will be read with interest :—

"As to new facts he noted—(1) that eyeball movements are got from ablated reptilian head, and cease on destruction of brain; (2) that opium increases reflexes though sedative to mind, *i.e.*, distinguished diastaltic from conscious channels; (3) that anencephalous fœtus moves to stimulation; (4) that strychnin picks out movements of 'diastaltic' order; (5) that reflexes can be excited easier from nerve-ends than from nerve trunks (he does not seem to have caught the significance of this); (6) that a tonus is exhibited by skeletal muscle which is maintained by diastaltic arc, and that sphincter tonus is of this nature. (His experiments give no *proof* that the tonus is in either case 'reflex' rather than 'automatic'; and his position was remote from to-day's, since he expressly denied Bell's muscular sense and existence of Bell's nerve-circuit, also existence of sensory nerves in muscle, and now, I suppose, most of us regard reflex tonus as maintained by muscular afferents acting on muscular efferents. And in regard to sphincter tonus, I suppose, Goltz's work makes rectal sphincter a 'myogenic' tonus.)

"Hall was of much service in boldly illustrating his physiological theories and observations by clinical examples. Also his bold treatment of the cerebro-spinal axis as *functionally* a segmental series helped greatly, I imagine, to establish that—most useful—point of view; but it was not original with him, *e.g.*, Legallois and Grainger. I fancy, too, that Hall was the first to speak at all clearly of 'spinal shock' phenomena, and to begin to distinguish between it and 'collapse' vascular.

"In his own estimation his chief advance lay in the doctrine of separateness in the central nervous system of the great sub-system for unconscious reflex action, and another great sub-system for sensation and volition. The two were, according to him, absolutely separate, at least if I read him aright. It seems never to have occurred to him that a peripheral nerve-fibre might, on entering a central nervous system, embouch into channels which led, on the one hand, into his one system, on the other hand into his other. Also he missed the important point that the two are so intermingled that many physiological processes pass from one to other; also that, psychologically, there are a number of reactions that lie intermediate between his extreme types, 'unconscious reflex' and 'willed action.' This narrowness of view was the more notable, because Grainger (1837) distinctly contended that the peripheral nerve led to both kinds of channels. But, altogether, I could not see any real difference between his (Marshall Hall's) view of movements of headless animals, &c., and those of many of his predecessors, Hales, Whytt, Prochaska, and even Descartes. Eckhard gives an interesting judgment of Hall in this regard (*Beiträge*, IX., 54, 1881)."

JOHN DALTON.

1766-1844.

THE *Memoirs of the Life and Scientific Researches of John Dalton* were issued by one whose name is written large in the scientific and medical history of Manchester—by Wm. Charles Henry, M.D., F.R.S. (Cavendish Society, 1854). I have thought it right to include Dalton amongst the Apostles for

JOHN DALTON.

many reasons, not the least of these being that Manchester was the first town in the provinces to found a thoroughly organized and fully equipped Medical School (1825)—then called the Pine Street School of Medicine—the school founded by the late Mr. Thomas Turner (1793–1873), in which Dalton taught Pharmaceutical Chemistry (1825).

J. E. PURKINJE.

1787–1869.

HE began life as a teacher, but, before doing so, took Orders. The writings of Fichte influenced him much, and he decided to follow medicine. He studied medicine in Prague from 1813, and in 1819 he became Prosector. His earliest work was entitled *Beiträge z. Kenntniss der Sehen in subjectiver Hinsicht* (Prag 1819). The work, dealing with subjective ocular phenomena, brought him the acquaintance, friendship, and support of Goethe, the result being that he obtained the Chair of Physiology and Pathology in Breslau, a Prussian University, in 1823, where he laboured for six-and-twenty years—founding what was, perhaps, the first physiological institute in Europe—until his return, in 1850, to Prague, as Professor of Physiology.

He was amongst the first to give methodical instruction in the use of the microscope for the investigation of the structure of tissues. "The Institute in Breslau was the cradle of Histology." Although he had a preference for the study of optical phenomena, and published *Beobachtungen u. Versuche d. Physiologie d. Sinne* (Berlin, 2 vols., 1823–26), he has left his mark on many other departments of physiology and histology—"Purkinje's cells" of the cerebellum; "Purkinje's fibres" of the heart. He made many researches on "development." In 1835, with Valentin, he published his famous article on ciliary motion. In 1837, two years before Schwann, he made investigations on the glands of the stomach and on gastric digestion.

His histological works deal with the skin, bone, nerve plexuses, axis cylinder, ganglion cells, compressorium, double knife for sections, chromate of potash, glacial acetic acid, heart fibres, muscular fibres, &c. An account of his scientific as well as his literary works will be found in the *Almanach d. k. Akad. d. Wiss.* (Wien 1870), and the story of his later years in the *Life of J. N. Czermak*, by Anton Springer.

K. E. VON BAER.

1792–1876.

WE have already mentioned how intimately the story of development and embryology is interwoven with that of advances in the healing art. Fabricius, Malpighi, Harvey, De Graaf, Haller, and many others were liberal contributors. Professor Oscar Hertwig, Director of the Biological Institute in Berlin, in the first part of his *Handbuch d. Vergl. u. exp. Entwickelungslehre d. Wirbelthiere* (1901), tells the story of this subject and gives a prominent place to Von Baer. Von Baer was born in Esthonia, he studied at the newly founded University of Dorpat (1810) —even the name Dorpat has disappeared, to-day it is Jurjev—and became Prosector in Königsberg under E. BURDACH (1801–1876).

In 1834 he accepted a "call" to St. Petersburg, where he laboured for thirty years "at once the joy and the pride—the soul of the Academy." In his later years he devoted himself largely to anthropology. We have spoken of De Graaf's work. It was not, however, until 1827, that it was shown by Von Baer that the Graafian follicle was not the real objective in the ovary, but that a much smaller body, the ovum, was the essential unit.

E. H. WEBER.

1795–1878.

THE lineal pedigree of physiology in Leipzig is from Ernst Heinrich Weber through Carl Ludwig to Ewald Hering. Nor must we forget the School of Psychology, which must ever be associated with the names of GUSTAV THEODOR FECHNER and WILHELM WUNDT and LÖTZE (of Halle). WEBER was born in Wittenberg, and graduated there. He went to Leipzig in 1817, where he became Professor of Anatomy and Physiology in 1821. These then joint offices he held until 1866, when a new Chair of Physiology was created for C. Ludwig. Weber retained the Chair of Anatomy until 1871, when he was succeeded by W. His, and, conjointly with His, by his son-in-law W. Braune. The work of E. H. Weber marks an epoch not only in physiology, but also in psychology. Apart from his contributions to anatomy,—his contributions to the physiology of movement, and above all arrest of movement, represented by the term "inhibition," stand out as a landmark in the progress of human thought.

His *Wellenlehre*, published in 1825 jointly with his brother Eduard, is a classic both in physics and physiology. It has been republished in Ostwald's collection *Klassiker, etc.*, by Von Frey (1889).

It was asserted by Bichat that the pulse is synchronous in all the arteries. Weber showed that this is not so, but that according to the distance from the heart there is a pulse delay of one-sixth to one-seventh of a second. Weber showed the true nature of the pulse wave as "the effect of the oscillation propagated along the coats of the arteries, and in the blood itself, in consequence of the pressure exerted upon the column of blood in the aorta by the heart in its contraction." From the pulse delay he calculated the velocity of propagation of the wave.

The velocity of the pulse wave was first measured directly by E. H. Weber, although in 1734 Weitbrecht of St. Petersburg had observed that the carotid precedes the radial pulse. Weber, by means of a watch that beat one-third seconds, found that the pulse in the anterior tibial artery was one-sixth to one-seventh of a second later than that in the maxillary. The distance between these two he took as 1·32 metres, and this gave a velocity for the pulse wave of 7·92 to 9·24 metres per second.

The year 1839 is a famous one in the history of physiology, for in March of that year Schwann published his famous *Untersuchungen* and Schleiden his *Beiträge zur Phytogenesis.* The latter occurs in the Müller's *Archiv* for this year, and in this same volume of the *Archiv* is Weber's classical paper *On the Movement of Lymph Corpuscles in Arteries and the velocity of blood in the capillaries.* Poiseuille before this time had described the space in the small arteries that bears his name. Weber and his brother studied the slow rolling movements "of the particles, which had the form of lymph corpuscles," and discusses the peculiarities of the rate and character of their movement. At the end of this communication he describes how in 1837 with his brother Eduard, then prosector in Leipzig, he studied the capillary circulation in a tadpole, "where the circulation is so slow that one can see the corpuscles moving, and compare their velocity with that of the lymph corpuscles at the walls of the vessel." Magnifying the parts 100 times he found the velocity to be ¼ P. Lin. per second, "a velocity so slow that if the corpuscles were large enough to be visible, one could scarcely detect the movement with the unaided eye." Perhaps some who have looked at the circulation in the web of a frog's foot have hardly realized this fact—1 inch in 48 seconds for the red, and 1 inch in 10 minutes for the lymph corpuscles. He imitated the velocity by mixing two drops of urine with a drop of blood, and observed by means of the microscope the rate of mixture. The movement was so slow as not to be visible to the naked eye.

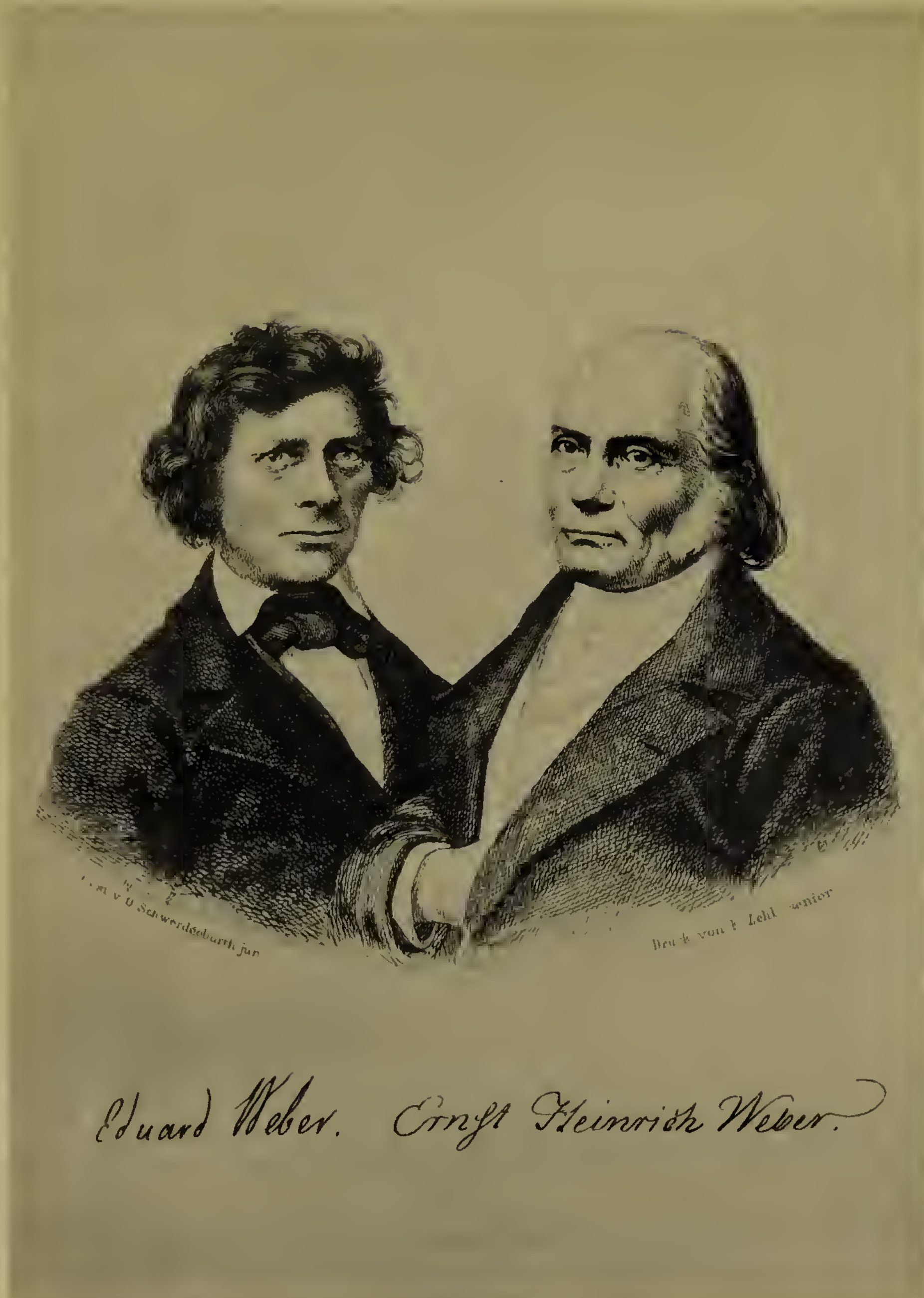
At Naples, in 1845, at the Congress of Italian scientists, E. H. Weber communicated the results obtained by himself and his brother Eduard by applying tetanizing induction shocks to the peripheral end of the vagus. Having regard to the fundamental importance of this experiment on "inhibition," I shall refer somewhat fully to this matter. I have not seen the original communication. It is published in an Italian journal (Omodei, *Annali di Medicina*). The following condensed account is based on the Article, *Muskelbewegung*, in Wagner's *Handwörterb. d. Physiologie*, Vol. III., pt. 2, p. 42, 1846.

"My brother and I found that stimulation of the *nervi vagi*, or of the parts of the brain from which they arise, causes slowing in the *tempo* of the rhythmical beats of the heart, or even causes the heart to stand still. This is the first experimental proof that the brain acts on the heart, that this action is due to the action of a nerve, which up to this time was not known to be connected with the action of the heart; that a nerve acting on a muscular organ does not cause movement of that muscle, but arrests—inhibits—a movement, is an altogether new and unexpected fact." "We used a magneto-electric apparatus. One pole was placed on the nose of a frog, the other on a cross section of the cord at the level of the fourth vertebra. On stimulating, after a beat or two, the heart ceased to beat, and remained quiescent for a few seconds after cessation of the stimuli. The heart began to beat first at one point, and feebly, and then finally resumed its normal beat. During the period of standstill of the heart, it was not contracted, but in diastole. It was flattened, soft, and gradually filled with blood. To ascertain which part of the central nervous system exerted this effect, the cord was divided at the occiput, and again stimulated, and with the same result, the poles being applied directly to the divided bulb. Another experiment showed that this inhibitory effect was obtained by applying the poles of the magneto-rotatory apparatus to any part, from the *corpora quadrigemina* to the *calamus scriptorius*. We found that the vagi were the channels of communication, and the action of both vagi was regarded as necessary to arrest the heart's action." [We know this is inaccurate, for shortly afterwards Budge (1846), M. Schiff (1849), and Ludwig and Hoffa (1849) arrested the heart's beat on stimulating one vagus in the frog, rabbit, and dog. The Webers obtained similar results in warm-blooded animals.]

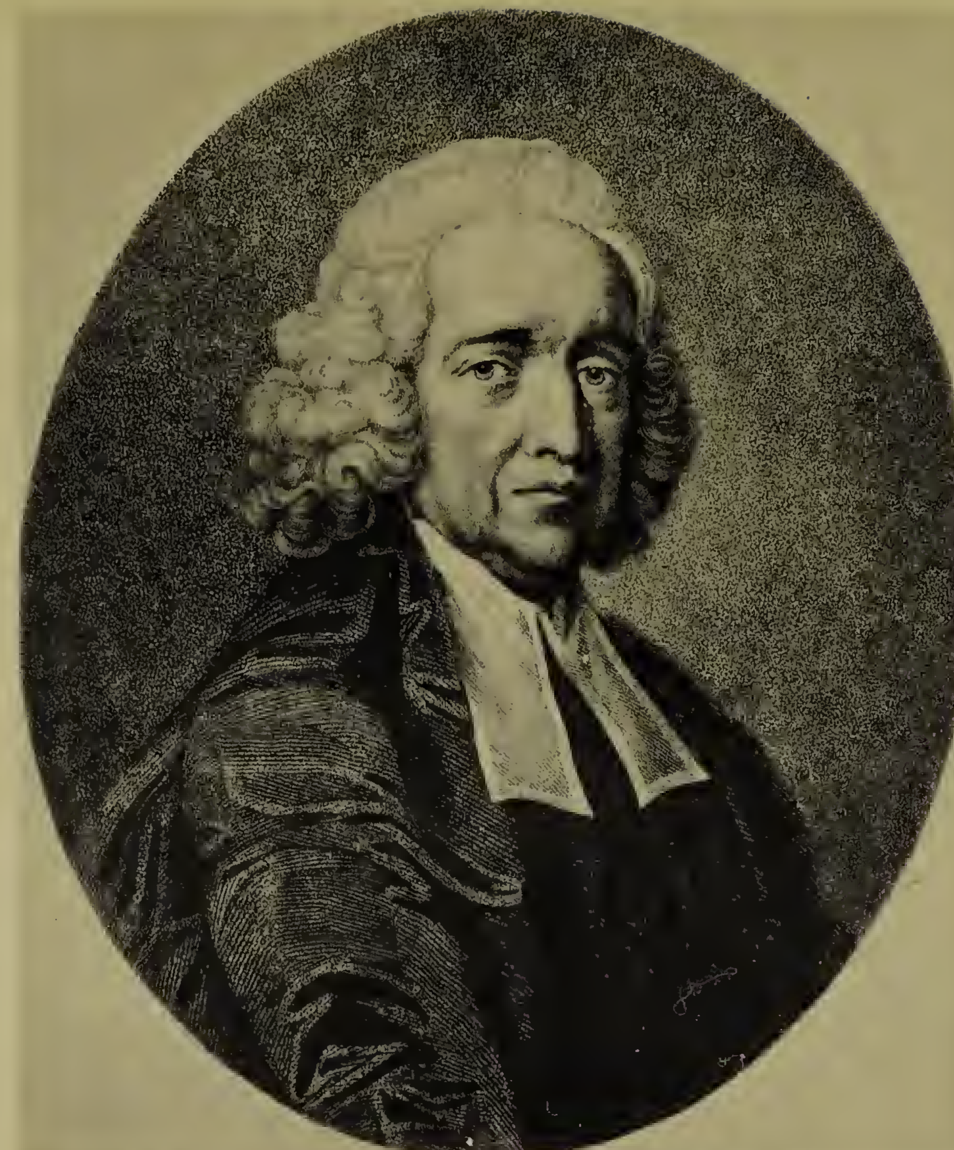
We need not pursue this aspect of the question further here, but before the full significance of the action of vagus in the heart could be studied much had to happen.

By the introduction of the graphic method, in 1847, by Ludwig, *i.e.*, two years after this discovery of the Webers, it became possible to record the effects of a make and break shock of a galvanic current. To get the full vagus effect rapid shocks were required. Indeed, Volkmann, in 1838, had used a rapidly interrupted galvanic current, but his results were unheeded.

IT was M. FARADAY'S discovery of induced electricity that made the application of rapidly repeated induction shock possible. This came effectively through the convenient and now universally employed inductorium of Du Bois-Reymond.



THE BROTHERS WEBER.



STEPHEN HALES.

CARL LUDWIG.

It may be of interest if I quote from *The English Malady, or Treatise of Nervous Diseases of all Kinds*, by G. Cheyne (1733), the famous case of Colonel Townshend.

" *Case of the Hon. Colonel Townshend.*—Colonel Townshend, a gentleman of excellent natural parts, and of great honour and integrity, had for many years been afflicted with a nephritick complaint, attended with constant vomitings, which had made his life painful and miserable. During the whole time of his illness, he had observed the strictest regimen, living on the softest vegetables and lightest animal foods, drinking ass's milk daily, even in the camp: and for common drink Bristol water, which, the summer before his death, he had drunk on the spot. But his illness increasing, and his strength decaying, he came from Bristol to Bath in a litter, in autumn, and lay at the Bell Inn. Dr. Baynard (who is since dead) and I were called to him, and attended him twice a day for about the space of a week, but his vomitings continuing still incessant, and obstinate against all remedies, we despaired of his recovery. While he was in this condition, he sent for us early one morning: we waited on him, with Mr. Skrine his apothecary (since dead also); we found his senses clear, and his mind calm, his nurse and several servants were about him. He had made his will and settled his affairs. He told us, he had sent for us to give him some account of an odd sensation he had for some time observed and felt in himself: which was, that composing himself, he could die or expire when he pleased, and yet by an effort or some how, he could come to life again: which it seems he had sometimes tried before he had sent for us. We heard this with surprise, but as it was not to be accounted for from now common principles, we could hardly believe the fact as he related it, much less give an account of it: unless he should please to make the experiment before us, which we were unwilling he should do, lest, in his weak condition, he might carry it too far. He continued to talk very distinctly and sensibly above a quarter of an hour about this (to him) surprising sensation, and insisted so much on our seeing the trial made, that we were at last forced to comply. We all three felt his pulse first: it was distinct, though small and thready: and his heart had its usual beating. He composed himself on his back, and lay in a still posture some time: while I held his right hand, Dr. Baynard laid his hand on his heart and Mr. Skrine held a clean looking-glass to his mouth. I found his pulse gradually, till at last I could not feel any, by the most exact and nice touch. Dr. Baynard could not feel the least motion of his heart, nor Mr. Skrine the least soil of breath on the bright mirror he held to his mouth; then each of us by turns examined his arm, heart, and breath, but could not by the nicest scrutiny discover the least symptom of life in him. We reasoned a long time about this odd appearance as well as we could, and all of us judging it inexplicable and unaccountable, and finding he still continued in that condition, we began to conclude that he had indeed carried the experiment too far, and at last were satisfied he was actually dead, and were just ready to leave him. This continued about half an hour. By nine o'clock in the morning in autumn, as we were going away, we observed some motion about the body, and, upon examination, found the pulse and the motion of his heart gradually returning: he began to breathe gently and speak softly: we were all astonished to the last degree at this unexpected change, and after some further conversation with him, and among ourselves, we went away fully satisfied as to all the particulars of this fact, but confounded and puzzled, and not able to form any rational scheme that might account for it. He afterwards called for his attorney, added a codicil to his will, settled legacies on his servants, received the sacrament, and calmly and composedly expired about five or six o'clock that evening. Next day he was opened (as he ordered); his body was the soundest and best made I had ever seen; his lungs were fair, large and sound, his heart big and strong, and his intestines sweet and clean; his stomach was of a due proportion, the coats sound and thick, and the villous membrane quite entire. But when we came to examine the kidneys, tho' the left was perfectly

sound and of a just size, the right was about four times as big, distended like a blown bladder, and yielding as if full of pap; he having often passed a wheyish liquor after his urine, during his illness. Upon opening this kidney, we found it quite full of a white chalky matter, like plaster of Paris, and all the fleshy substance dissolved and worn away, by what I called a nephritick cancer. This had been the source of all his misery; and the symptomatick vomitings from the irritations on the consentient nerves, had quite starved and worn him down. I have narrated the facts, as I saw and observed them deliberately and distinctly, and shall leave to the philosophic reader to make what inferences he thinks fit; the truth of the material circumstances I will warrant."

But perhaps his investigations on the senses are those best known. Rudolph Wagner's *Handwörterbuch der Physiologie* (1842–53) contains essays from the pen of the then most renowned physiologists. It was the successor of Todd's *Cyclopædia of Anatomy and Physiology* (1836–59). His collected works were published in 1851. There will be found his important observation on glands. In the *Handwörterbuch* one finds Weber's classical contributions to *Tastsinn und Gemeingefühl* or *Touch and Common Sensation,* Vol. III., 2. 481 (1846). Psychology was, largely through his investigations and those of the Leipzig School, put upon a physiological basis. "Weber's law" and "Fechner's law" are significant of the important part played by the direct estimation of physiological facts in their bearing on psychological phenomena; they indicate where physiology and psychology touch, over-lap, and in fact integrate.

ED. FR. WEBER, of Halle, a younger brother (1806–1871), wrote the article *Muskelbewegung* in Wagner's *Dictionary,* and jointly with a still more famous brother, Wilhelm, *Mechanik d. mensch. Geh-Werkzeuge* (Göttingen 1836), which includes an analysis of locomotion and intricate studies on the mechanism of joints. It is a far stride from the Webers to Professors E. J. Marey and J. Chauveau, both of Paris, still happily amongst us. It was just this question of the study of the pulse that led up to Marey's method of transmission of movement in air. The study of the pulse could only be taken up scientifically after Weber had developed his doctrine (1850) of the theory of waves in elastic tubes, and after KARL VON VIERORDT (1818–1884) had invented his sphygmograph, albeit a heavy equipoised system of levers with a button resting on the radial artery. (*Die Lehre v. Arterienpuls,* &c., 1855.) Settling first as a physician in Karlsruhe, Vierordt's works on carbonic acid, in respiration, and his article *Respiration* in Wagner's *Handwörterbuch* (1846) brought him the Chair of Physiology in Tübingen. He was one of the earliest to enumerate the blood corpuscles, he founded sphygmography, used largely spectroscopic analysis for physiological purposes, and in all published over one hundred memoirs.

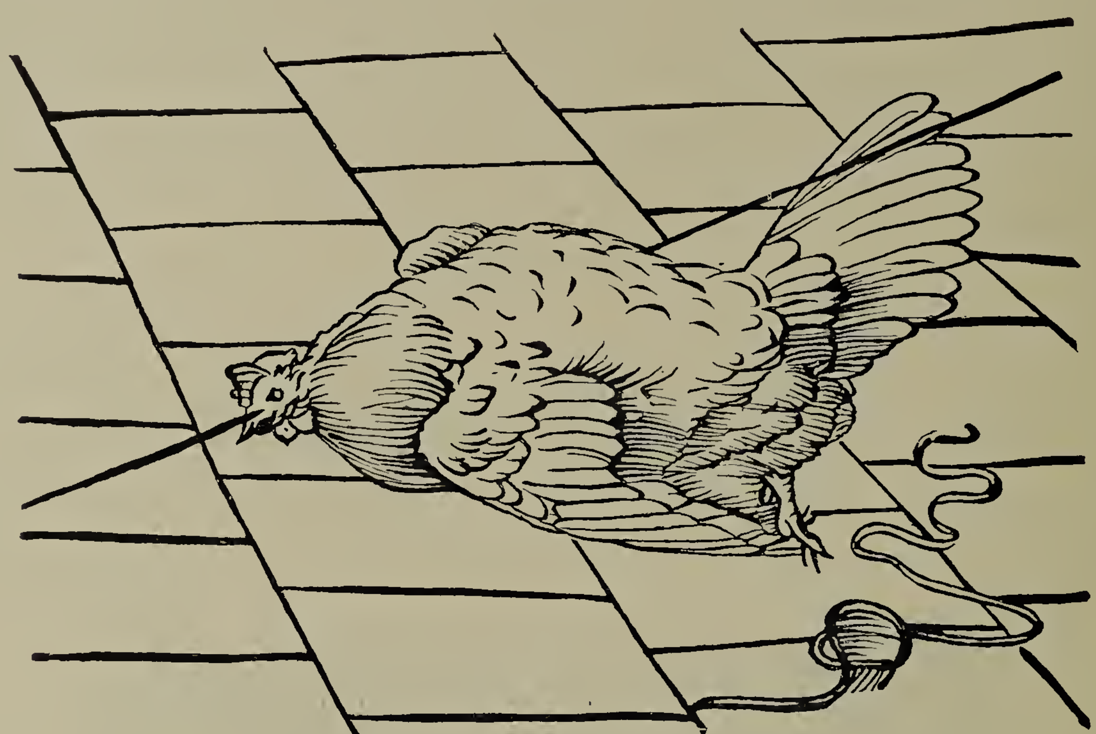
J. E. MAREY (b. Beaune, Côte-d'Or, 1830) in 1860 published an account of the sphygmograph that bears his name. I need not dwell on his method of air transmission, tambours, and all that he and Chauveau have done for the advancement of physiology, and above all for the graphic method. England gave the impulse, Ludwig wrote the blood pressure in terms of millimetres of mercury, the transmission of movements was in the air, and Marey made the air subservient to the transmission of movement.

WHILE dealing with these remarkable phenomena of inhibition, it may be not uninteresting to give a picture of the famous Jesuit ATHANASIUS KIRCHER (1602–1680), who was born near Eisnach, joined the order of the Jesuits, was Professor in Würzburg in 1631, where he published his *Ars Magnesia,* dealing

ATHANASIUS KIRCHER.

with "Magnetismus." He soon left Würzburg, and ultimately, through the influence of Cardinal Berberini, he was for some years teacher of

mathematics in the " Collegium Romanum " in Rome. In his later years he greatly added to the collection that still bears his name, " Museum Kircherianum," in Rome. Classical scholar, Egyptologist, astrologist,



KIRCHER'S "EXPERIMENTUM MIRABILE," FROM THE ORIGINAL FIGURE.

mathematician, &c., his name remains also associated with the " experimentum mirabile " on a fowl—the early experiment on hypnotism. The portrait is taken from his remarkable work, *Mundus Subterraneus* (1665), and the experiment from his *Physiol. Kircheriana* (1680). I need only refer to the recent work on this subject by my friend Professor M. Verworn, of Göttingen.

JOHANNES MÜLLER.

1801-1858.

ONE of the greatest Biologists of the last or any century was born the son of a shoemaker at Coblenz, one year before Sharpey, and just one after the death of Bichat. His early academic days were spent at Bonn (1819), where the study of theology, as is not unfrequently the case, led him to medicine. As showing his physiological bias his first essay—which gained a prize—*Respiration of the Fœtus*, was published in 1823. Müller went to Berlin to pass his examination, and, while there, came under the influence of Rudolphi. Müller himself says of Rudolphi, " Er hat meine Neigung zur Anatomie mitbegrundet, und für immer entschieden." In 1824 he returned to Bonn, became a *Privatdocent*, Professor in 1826. In 1833 he was called to Berlin as Director of the Anatomical School and Museum. He died suddenly in 1858.

He taught anatomy, human and comparative, pathology. Physiology, and comparative anatomy, however, were his beloved

JOHANNES MÜLLER.

J. E. PURKINJE.

KARL ERNST V. BAER

objects of study. The first half of his scientific career he dealt chiefly with physiological problems, and in the latter half with those of comparative anatomy. He added enormously to his great Museum of Human and Comparative Anatomy in Berlin.

Regarding the minute structure of glands, his monograph *De Gland. secern. Structurâ penitiori* (Lip. 1830) marks an epoch. He supported the view of E. H. Weber that the gland acini are the direct continuation of the ducts, and he showed the exact relation of the capillaries to the acini themselves. As we have already stated, the first researches were those of Malpighi published in 1665. Ruysch attributed great importance to the blood vessels of the acini, and Haller endorsed his view. Mascagni and Cruickshank had shown that the secreting canals in the mammary gland commenced in cells, and E. H. Weber had shown that the same was the case in salivary glands and pancreas of birds. Müller's monograph ranges over all the glands, and deals with those both of vertebrate and invertebrate animals. He shows how the acini are closed save where they open into a duct, and how the blood-vessels ramify outside the membrane of the acini. An abridgment of this work was published in 1839, *The Intimate Structure of Secreting-glands*, by Samuel Solly. On plate iii., Fig. 8, we have one of the solitary follicles, from the mucous membrane of the rectum represented as containing a cavity opening by a constricted orifice. In embryology his name is associated with the "Müllerian duct." "Richard Owen and Müller must be regarded as the founders of modern comparative anatomy, which largely depends on the study of embryology, and on the investigation of simpler forms." His chief work in this respect, *Vergleichende Anatomie d. Myxinoiden*, is and must remain a classic. While in Bonn he discovered and wrote upon certain of the lymph hearts in the frog and tortoise: *On the existence of four distinct Hearts, having regular pulsations, connected with the Lymphatic System in certain Amphibious Animals.* (*Phil. Trans.*, 1833.) It was Marshall Hall's *Essay on Circulation of the Blood*, 1831, which led Müller to discover the lymph hearts in 1832.

As regards his influence on physiological doctrine, he is the representative of "Vitalismus." There was a certain mystic element in Müller's nature, and he wrote a remarkable work on apparitions, *Phantastische Gesichts Erscheinungen* (Coblenz 1826). While in Bonn he used the frog to test the truth of Bell's law.

"The happy thought at length occurred to me of performing the experiment on frogs. The result was most satisfactory. The experiments are so easily performed, so certain and conclusive, that every one can now very readily convince himself of one of the most important truths of physiology. . . . It is quite impossible to excite muscular contractions in frogs by irritating mechanically the posterior roots of the spinal nerves; while, on the other hand, the slightest irritation of the anterior roots immediately gives rise to strong action of the muscles. . . . The application of galvanism to the anterior roots of the spinal nerves, after their connection with the cord is divided,

excites violent muscular twitchings; the same stimulus applied to the posterior roots is attended with no such effect. . . . If in the same frog the three posterior roots of the nerves going to the hinder extremities be divided on the left side, and the three anterior roots on the right side, the left extremity will be deprived of sensation, the right of motion." (*Physiology*, pp. 692–694.)

He had a clear conception of reflex action, studied the problems of consensual movement and excentric sensation, formulated the law of "specific energies" for the sense organs, made fundamental observations on the production of voice, and conduction of sound in the tympanum.

With Purkinje he was amongst the first to apply the microscope to the study of animal tissues, and helped his pupils to build up modern histology. He recognised the resemblance between the cells of the *chorda dorsalis* and those of plants. He gave careful descriptions of the structure of cartilage cells, recognising their nucleus, and was the first to prepare chondrin. He grouped the cellular tissues with others to form the "Bindegewebe" or connective tissues. He made experiments on blood coagulation, resuscitated the experiments and observations of Wm. Hewson, and helped Schwann to his discoveries on digestion.

His work, *Elements of Physiology*, so far as it goes, is still unsurpassed, and contains a mine of information. At the suggestion of Dr. George Burrows, it was translated by Dr. Wm. Baly, 1st ed., 1837, 2nd ed., 1840.

As showing the titanic might of his genius and industry, in twenty-five years he published over two hundred papers, besides doing all his other work. Amongst his pupils may be mentioned Schwann, Henle, Brücke, Du Bois-Reymond, Virchow, Helmholtz, Claparède, Reichert, Lieberkühn, R. Remak, &c.

THEODOR SCHWANN.

1810-1882.

ALTHOUGH Schwann spent the greater part of his life in Belgium, his work was done in Berlin, when Johannes Müller was Professor and J. Henle Prosector. The fifth child amongst thirteen, Schwann was born at Neuss near Dusseldorff. Cologne is associated with his early days, when he attended the College of the Jesuits; and in Cologne he died. The religious, the theological factor, was a powerful and dominant one in Schwann. He entered the University of Bonn in 1829, where he had the good fortune to become a pupil of Johannes Müller. "This event fixed his destiny." He determined to study medicine. While there he witnessed Müller's experiments on the spinal nerve roots of the frog. After

leaving Bonn, he passed three terms at Würzburg, and then went to Berlin for his examinations (1834), where he found Müller, who had become Professor of Anatomy and Physiology, as successor to Rudolphi, and Henle as his assistant.

"I can picture him as a man under middle height, beardless, with an almost infantile countenance, and a lively, smiling expression, brownish hair, clad in a fur coat, and living in a small dingy back room on the second floor of a not-quite second class restaurant (corner of Friedrich- und Mohrenstrasse). There he remained sometimes for days, surrounded by a few books, and innumerable glass bulbs, tubes, and much primitive apparatus made by himself. Or I transport myself in imagination to the dark, sombre room euphemistically called an Anatomical Institute, situated behind the 'Garnison-kirche,' where we worked till nightfall alongside our excellent *chef* Johannes Müller. In the evening we dined, English fashion, in order to take full advantage of the daylight. We lunched with the director in his room at midday, the wife of the porter supplying the food, and we the wine and the jokes."

"These were the happy days, which the present generation may well envy us, happy days when one had the first good microscopes from the workshop of Plössl in Vienna, or Pistor and Schiek in Berlin, which we paid for by our small savings; these the days when it was possible to make discoveries of the first order by scratching an animal membrane with the nail or with the belly of a scalpel. Schwann busied himself vigorously with the microscopic investigations instigated by Müller, but with even more energy he pursued experimental physiology."

This is the account given by J. HENLE (1809-1885) in *Archiv f. mik. Anat.*, XXIX., 1882.

From 1834 he was Prosector in the Anatomical Museum at the magnificent salary of ten thalers—thirty shillings—a month. In 1839 he accepted a call to the Catholic University of Louvain, where he remained until 1848, when he was invited to Liège, where he was at first Professor of General and Special Anatomy, and, after ten years, Professor of Physiology.

About 1837 Müller was engaged in writing the part of his Handbook dealing with physiology of muscle and nerve. According to Henle, Schwann's view is that a muscle fibre (*Muskelbündel*) is made up of parallel fibrillæ, and that the transversely striated appearance is the expression of a similar striation of the fibrils. He was the first to find striped muscles in the upper half of the œsophagus, and in the so-called erectile appendages of the turkey (Henle). As to nerve, who does not know the sheaths of the axis cylinder that bear his name? In this connection we must not forget the work of Purkinje and Remak.

The question of spontaneous generation takes one back to the time of Redi and Spallanzani, to Needham and Buffon, and to Ehrenberg. Ehrenberg from 1830 combated the idea of spontaneous generation of infusoria. About the same time F. Schultze (Poggendorff's *Annalen*, 1836) and Schwann (1837) attacked this

question, more especially as regards the part played by oxygen in the process. They showed that a fluid did not undergo putrefaction if the air admitted to it was passed through bulbs containing potash and sulphuric acid, or heated.

Next Schwann took up the question of vinous fermentation, and, on investigating yeast with the microscope, rediscovered the yeast plant simultaneously with Cagniard Latour. Leeuwenhoek had already seen yeast plants, but had mistaken them for crystals. Schwann devised a simple yet striking experiment to show the direct action of the yeast on a solution of sugar by splitting it up into carbonic acid and alcohol. In a long tube he placed a solution of sugar faintly tinged blue with litmus, and to this he added very little yeast, so that the cells had time to subside. The red colouration of the litmus due to the liberation of the carbonic acid always began to appear at the bottom of the tube.

In his inaugural dissertation he showed the necessity of air for the development of the chick *in ovo*, and in his disputation we find "Infusoria non oriuntur generatione æquivoca," showing that his mind had been directed to this subject.

His researches on artificial gastric digestion, an extension of those of Spallanzani, and Eberle of Würzburg (1834), and Purkinje (1837), made it evident that the digestive principle was not to be sought for in the mucus, but in some other as yet unknown body—a body which he called pepsin. He had discovered an impure form of one member of the inorganic ferments now known as enzymes, to use the word coined by W. KÜHNE (1837–1900). We have purposely omitted references to biliary and gastric fistulæ, to Beaumont's work, derived from a study of the case of Alexis St. Martin, and much else bearing on this subject.

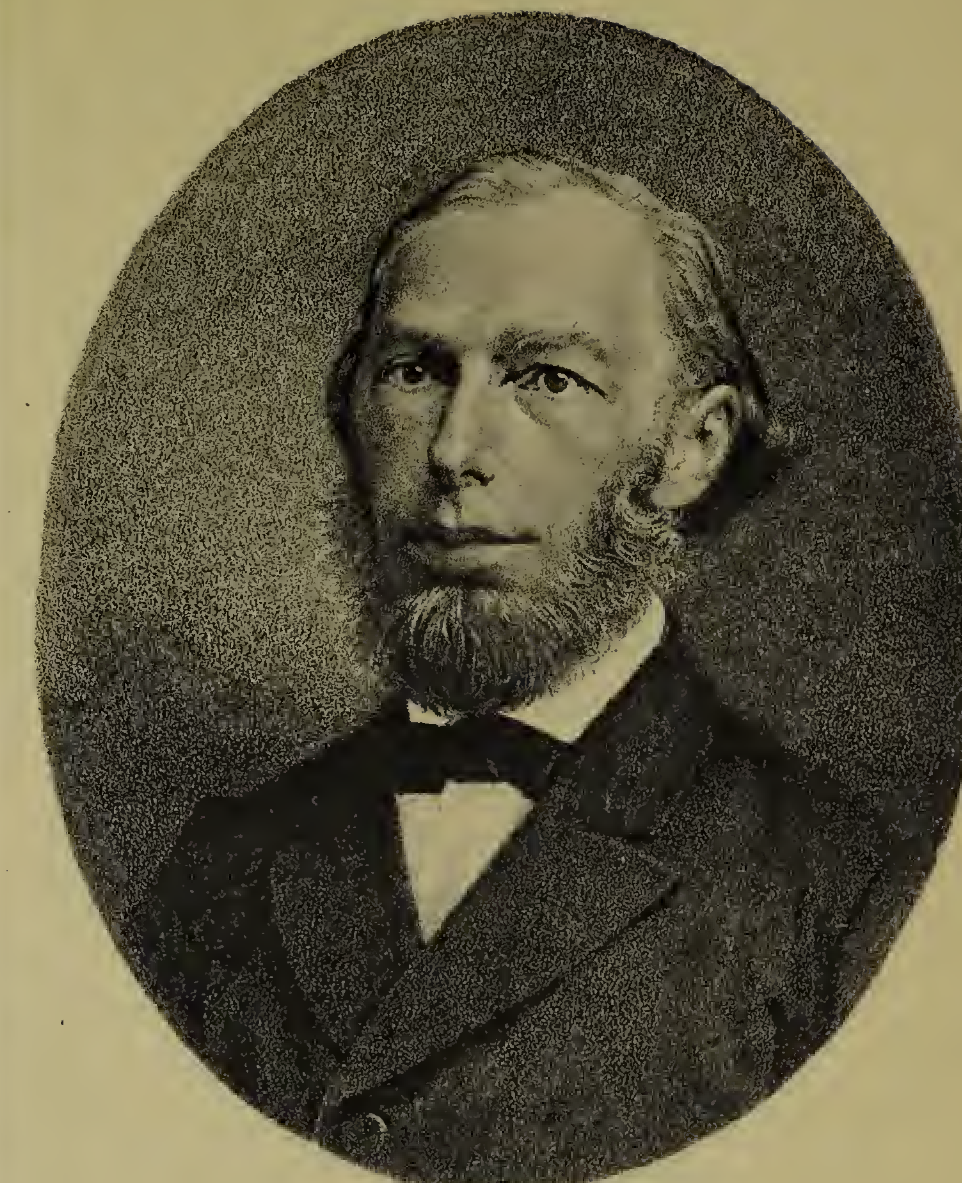
As to the nature of this body, Müller and Schwann regarded it as a ferment. At this time Mitscherlich explained fermentation as due to "contact." Schwann showed that acidity was necessary to the action of pepsin, and in his researches compared fermentation and digestion, distinguishing them from putrefaction.

Here we come across LIEBIG (1803–1873) as an opponent of Schwann's doctrine; for, according to Liebig, fermentation was not due to the presence of lowly organisms.

"But the great merit of Schwann rests on his 'cell-theory,' enunciated in 1839, whereby he brought the formation of all tissues—vegetable and animal alike—under one common law. To be sure, Schleiden, in 1838 had recognised and described the process of development in the cells of plants. But Schwann saw clearly the unity of the vegetable and animal processes, and formulated his 'theoria,' 'that there is one universal principle of development for the elementary parts of organisms, however different, and that this principle is the formation of cells.' It is stated that Schwann submitted the MS. of his work before publication, to the Bishop of Maline.

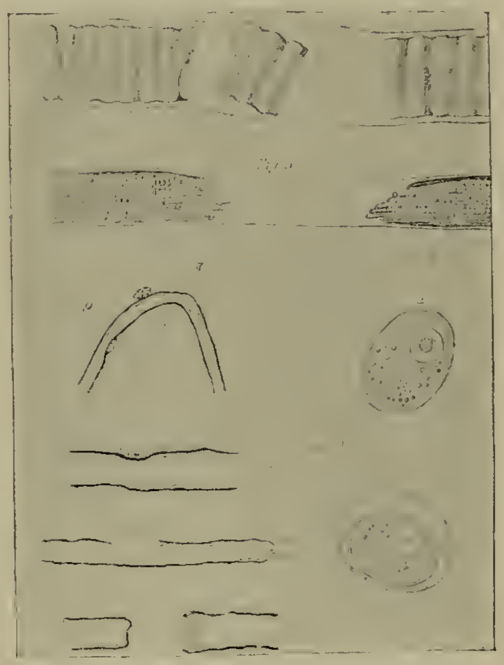

M. J. SCHLEIDEN.


T. SCHWANN.


MAX SCHULTZE.

"It is not to be imagined, however, that the whole of the credit is due to Schwann. Much had been done before his time by the English botanist, R. Brown, who discovered the nucleus in vegetable cells, in 1831; by Schleiden; by G. Valentin, who discovered the nucleolus in 1836; Henle, Purkinje, and many others, but the soil was ready, and Schwann grasped the situation at the psychological moment. His theory as to the origin of cells from a 'blastema' was, however, nothing more than an ingenious, but utterly fallacious speculation. This doctrine of Schwann's was absolutely denied by Virchow, who paraphrasing the original statement of Redi and Harvey, '*omne vivum ex ovo*,' said '*omnis cellula e cellula*,' *i.e.*, every cell comes from a pre-existing cell. After 1840 a period of great activity set in, marked by the work of Martin Barry, R. Remak, J. Goodsir, Naegeli, Max Schultze, L. Beale, Leydig, Kölliker, and many others upon the structure and mode of development of the cell. Schwann, like Bernard, did his great work early in his career."

Twenty years later it was reserved for the now venerable R. VIRCHOW, who celebrated his eightieth birthday on 12th October last, to apply the doctrine to the production of cells under abnormal conditions.



SCHWANN'S ORIGINAL FIGURE OF MUSCLE AND NERVE.

"His famous work on *Cellular Pathology* was published in 1858—the year in which the 'Theory of Natural Selection' was propounded independently by Darwin and Wallace. The second edition, translated by Chance, was dedicated to John Goodsir. Goodsir, indeed, in 1845, had shown that the nucleus divides, and is the 'germinal centre of the cell.' Both Martin Barry and R. Remak had noticed division of the nucleus in 1841." (W. S. in *Med. Chronicle*, 1901.)

Schwann's work was published in 1839, and became available for English readers as *Microscopical Researches into the Accordance in the Structure and Growth of Animals and Plants*, by Th. Schwann, trans. by H. Smith, F.R.C.S. (Sydenham Soc., 1847).

M. J. SCHLEIDEN.

1804–1881.

THE names of Schleiden and Schwann are linked together in connection with the cell-theory. The former was born at Hamburg in 1804, studied at Heidelberg from 1824 to 1827, when he graduated as Doctor of Laws. In 1833, he studied medicine in Göttingen, and then went to Berlin and, under his uncle Horkel, applied himself to natural science, but especially to botany. In 1839

he was Extraordinary Professor of Botany in Jena, where he published his *Phytotomy*. Returning to Dresden in 1862, he in 1863 accepted the Chair of Vegetable Chemistry and Anthropology in Dorpat, but this he soon resigned and returned to Dresden, and died in 1881. His chief works are, *Grundzüge der wissenschaftlichen Botanik*, 1842–43, and *Die Pflanze und ihr Leben*.

MAX SCHULTZE.

1825–1874.

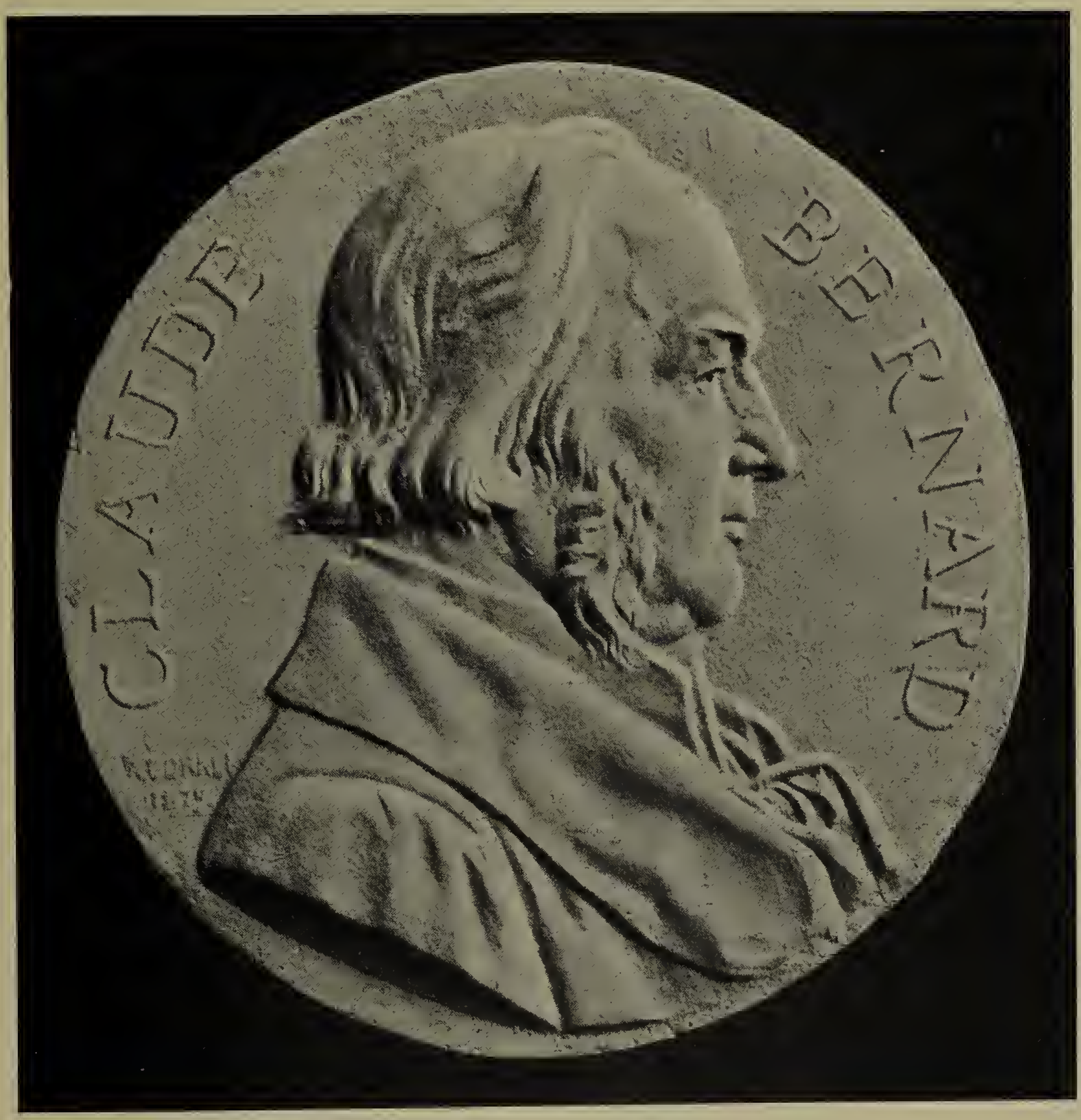
BORN in Freiburg in Breisgau, his early days were passed in Greifswald, but the star of Müller in Berlin was then attracting the younger Biologists in 1846–47. He diligently studied chemistry with a view to its application to histological problems, and later, in Greifswald, zoological problems attracted his attention; and, indeed, it was his researches on the rhizopods, which led to his modifications in the cell theory. It was evident that the presence of a cell membrane was not necessary to the conception of a cell.

He became Professor in Halle in 1854, where, under most unfavourable circumstances, he published papers on the development of petromyzon, on electrical organs, and a whole series on the termination of nerves in the sense organs, and soon he became one of the best known of the younger investigators. When Helmholtz went to Heidelberg in 1859, Schultze took up anatomy in Bonn. Here he published many important papers on the retina and cognate subjects. In 1861 his important work, *Ueber Muskelkörperchen, und das was man eine Zelle zu nennen habe*, was published. He and Brücke independently established the doctrine of cells as elementary organisms. The practical identity of the protoplasm of rhizopods with that of vegetables led him to study the movements of protoplasm—a term first used by H. von Mohl—and, in so doing, he observed the leucocytes with special precautions, being the first to use a hot stage for this purpose (1863). His controversy with Reichert regarding the cell indirectly led to the foundation of his *Archiv f. mikroskopische Anatomie* in 1865, and the first paper therein is his description of a "hot stage for the investigation of the blood." Dilute chromic acid, iodized serum, osmic acid, were introduced into histological technique through him. Just when he had completed the construction of the new Anatomical Institute in Bonn he died suddenly from a perforating ulcer of the duodenum. "Die Uhr stand still, der Zeiger fiel, es war vollbracht."

CLAUDE BERNARD.

1813-1877.

BERNARD was born in the district of St. Julien (Rhône), and Marey in that of Beaune. Bernard's earlier days were spent in Lyons, where he was assistant to a pharmacist. At first he thought of the drama, and, indeed, wrote a vaudeville, *La Rose du Rhône,* and, later, *Arthur de Bretagne* (published 1886). He went to Paris and began to study medicine, helping to keep himself by giving private tuition. After passing his examination he became "interne" or House Physician to Magendie at the Hôtel-Dieu, and in



1841 *Préparateur* to Magendie in the Collège de France. At that time Johannes Müller was the leader of physiological thought in Germany, E. H. Weber was making many experiments by applying the laws of physics to physiological phenomena, Henle, Remak, and others were dealing with microscopical problems, Schwann had published his cell theory and his discoveries in gastric digestion, Magendie his work on physical phenomena, Tiedemann and Gmelin their work on absorption. All these works had a more or less

physical trend. Marshall Hall was following up the work of Ch. Bell on reflexes. Wm. Bowman published his paper on striped muscle in 1840 and his work on the kidney in 1842. But that great quartette—Helmholtz, Ludwig, Du Bois-Reymond, and E. Brücke—had not begun their life-work.

In his thesis for the M.D., *On the Gastric Juice and its rôle in digestion,* we find the germ of one of his great discoveries. He found that cane sugar injected into the blood-vessels is excreted in the urine, but that this is not the case if it is previously acted on by the gastric juice. The next fertile discovery was made when, along with Barreswill, he was experimenting on digestion in graminivorous and carnivorous animals. In the dog, after a full meal, the lacteals were white immediately below the entrance of the bile duct and the pancreatic duct, which opens along with it. In the rabbit no chyle was seen save in the lacteals below the entrance of the pancreatic duct. In the rabbit the main pancreatic duct opens apart about 30 cm. below the pylorus. This led to his investigations on the pancreas (*Leçons de Physiol. Expér.,* 1855). It should be noted that this is not invariably the case. Bernard's work on the pancreas was begun before 1848, but it was not until 1856 that the full work appeared as a supplement to the *Comptes Rendus*—a memoir subsequently published (4to), to which in 1850 the Académie des

BERNARD'S FIGURE OF LACTEALS IN RABBIT DURING DIGESTION, WHITE BELOW ENTRANCE OF PANCREATIC DUCT.

BERNARD'S FIGURE OF LACTEALS IN A DOG, WHITE BELOW ENTRANCE OF PANCREATIC DUCT.

Sciences awarded the prize for Experimental Physiology. As already recorded, when writing of De Graaf (1662), it may be said that Bernard took up the story in the direct line. I have reproduced from this memoir two figures—the one from a dog, and the other from a rabbit. In the original of the dog Bernard gives two coloured figures showing the pancreas during digestion and at rest in the living animal. He also figures the "granules" of the pancreas that bear his name, and also the glands of Brunner.

Bernard's work is associated with three great problems—pancreatic secretion, glycogen, and vaso-motor nerves. His discovery of glycogen was not obtained by a frontal attack, he was led to it indirectly. At this time the combined results of histological and chemical investigation tended to show more and more the importance of the cell. Liebig and Wöhler were the heads of the German, and Jean Baptiste Dumas of the French school. In fact Dumas talked of the "balance of organic nature." There was supposed to be a complete contrast between animal and vegetable organisms. Indeed, the possibility of the actual formation of fat, or sugar or starch, was scarcely credited. Magendie knew that minute traces of sugar occurred in the blood, and it was supposed that this sugar came from the food. In 1848, Bernard, when studying the absorption of sugar from the intestine, thought that it might have some other source. With his friend Barreswill—the latter gives his name to a fluid test for grape sugar nearly identical with Fehling's solution—he found that the hepatic vein contained more sugar than the portal vein. Moreover, if an animal be fed on food containing neither starch nor sugar, or if it be starved, sugar is still found in the hepatic vein. The liver therefore, besides forming bile, makes sugar, which it pours into the blood. At one blow the artificial distinction between the animal and vegetable kingdoms was swept away. Of course such a complete reversal of established dogma was not accepted without much controversy. Bernard washed out the blood-vessels of an excised liver with water, until the washings gave no trace of sugar. On exposing the liver for a few hours to its normal temperature, washing out its vessels again, there was an abundance of sugar. There was no denying the fact that animal cells did produce sugar. The next thing was to isolate the substance from the liver. Bernard isolated glycogen by the potash-alcohol process in 1857. This substance was also isolated by Hensen. He sought to find out under what conditions glycogen is formed, and soon he showed the analogy between conversion of glycogen into glucose and of starch into sugar in potato, bulb of hyacinth, &c. He spoke of this conversion as "germination animale." These views led him to study animal heat, its sources and distribution. He saw that the amount of heat is a measure of the chemical activity of cells. Whilst searching for the influence of

nerves on glands, it occurred to him that the vagus might be concerned in the secretion of glycogen in liver cells. He had previously found that section of one of the peduncles of the cerebellum was followed by the appearance of sugar in the urine. On puncturing the floor of the fourth ventricle so as to injure the origin of the vagus, he produced artificial glycosuria, or, as it is sometimes called, experimental diabetes (1849). Later he discovered that this effect was not brought about through the action of the vagus, but by another channel. These experiments also upset the old view, one organ one function. The liver clearly was now restored to its high estate—the obsequies of Bartholinus were premature—the liver formed an "internal secretion," which it poured into the blood, and not into a duct. His successor in the Collège de France, BROWN-SÉQUARD (1818–1894), by his researches on the supra-renal and other glands, added much to our knowledge of this subject.

The glycogenic function of cells was soon extended to muscle, placenta, and all embryonic tissues, and in this matter Bernard had the advantage of the skill of WILLY KÜHNE (1837–1900), who was then working in Bernard's laboratory—Kühne, the genial and learned Professor of Physiology in Heidelberg, whose loss only two years ago we had to deplore. Kühne's own work on muscle, nerves, pancreatic and gastric digestion, and enzymes, and his histological contributions mark him out as a worthy pupil of the schools of Berlin and Paris.

Bernard's other great discovery is in relation to vaso-motor nerves, in 1851. Hunter knew that arteries were contractile. Bichat and Magendie refused to admit this. Dupuy, of Alfort, made experiments on the action of the nervous system on blood-vessels (1816). Purfour du Petit, in 1727, divided the cervical sympathetic nerve in the dog, and found redness of the conjunctiva ("the intercostal furnishes spirits to the eyes, to the glands and vessels of these parts"). Cruickshank, Brachet (1837), John Reid (1838), and others made similar experiments. Henle, in 1840, showed that the so-called muscular coat was composed of smooth or organic muscular fibres; Stilling was the first to use the term "vaso-motor." Henle and Stilling were led to surmise the relation of these nerves to the circular muscular coat and their action on blood-vessels. But Bernard's experiments and his new researches on the cervical sympathetic were the first experimental proof of the action of these nerves. His attention was strongly directed to the heat effects, and, later, he speaks of "calorific nerves," and even of "frigorific nerves."

In 1852 Brown-Séquard, in America (*Phil. Med. Examiner*), observed that section of the sympathetic was followed by dilatation of vessels and rise of temperature of the corresponding side of the head, while electrification of the upper end of the nerve caused constriction

CLAUDE BERNARD.

PIERRE PETIT, PHOT.

L. PASTEUR.

of the vessels and fall of temperature. Bernard also, in 1852, arrived at the same result. The observations of the earlier experimenters referred more to the state of the pupil than to that of the blood-vessels. A. Waller, in 1853, traced the nerves to his cilio-spinal region of the cord. Bernard clung tenaciously to his first idea of the effect of the sympathetic nerves on temperature.

In 1858, while trying to discover the condition of the blood escaping from glands during rest and activity, by experimenting on the *chorda tympani* he found that the blood-vessels were dilated and that the blood flowed out red from the sub-maxillary gland. On stimulating the sympathetic the blood was scanty and dark-coloured. He had discovered the other factor, viz., vaso-dilator nerves, and that each gland is supplied by vaso-constrictor and vaso-dilator fibres.

We have not space to refer to the other works of Bernard—to his work on heat and poisons. He showed that carbonic oxide combined firmly with the hæmoglobin of the red blood corpuscles and thus caused death by asphyxia; the tripod of life of Bichat was upset. He also showed that curare acted on the intra-muscular parts of the nerves, and thus set at rest the old question of "independent muscular excitability," a problem that involved a war of words between Whytt and Haller. He showed the identity of animal and vegetable processes.

Indeed, in 1846, he had even shown that stimulation of the vagus arrested the heart and that its section (1849) made the heart beat quicker; that the respiratory movements were arrested by stimulation of the superior laryngeal nerve (1853). There were all the data for the discovery of inhibitory nerves; but his mind was preoccupied with other matters. He contented himself with stating the facts. These facts are taken from *L'Œuvre de Claude Bernard* (1881). Any one interested in the story of his life-work will find it in that volume, which contains—First, the éloge of E. Renan, who succeeded Bernard as Membre de l'Académie Française; the discourse pronounced at his funeral by his favourite pupil, Paul Bert, and the analytical table of his works (p. 97 to p. 333); the Bibliography of his Scientific Work, p. 337 to p. 384. He published in seventeen octavo volumes his lectures given at the Collège de France, at the Sorbonne, and the Museum. The charmingly written Life of Bernard, by Sir Michael Foster, in the series *Masters of Medicine* (1899), gives a graphic picture of the man and his works by one "who never saw his face."

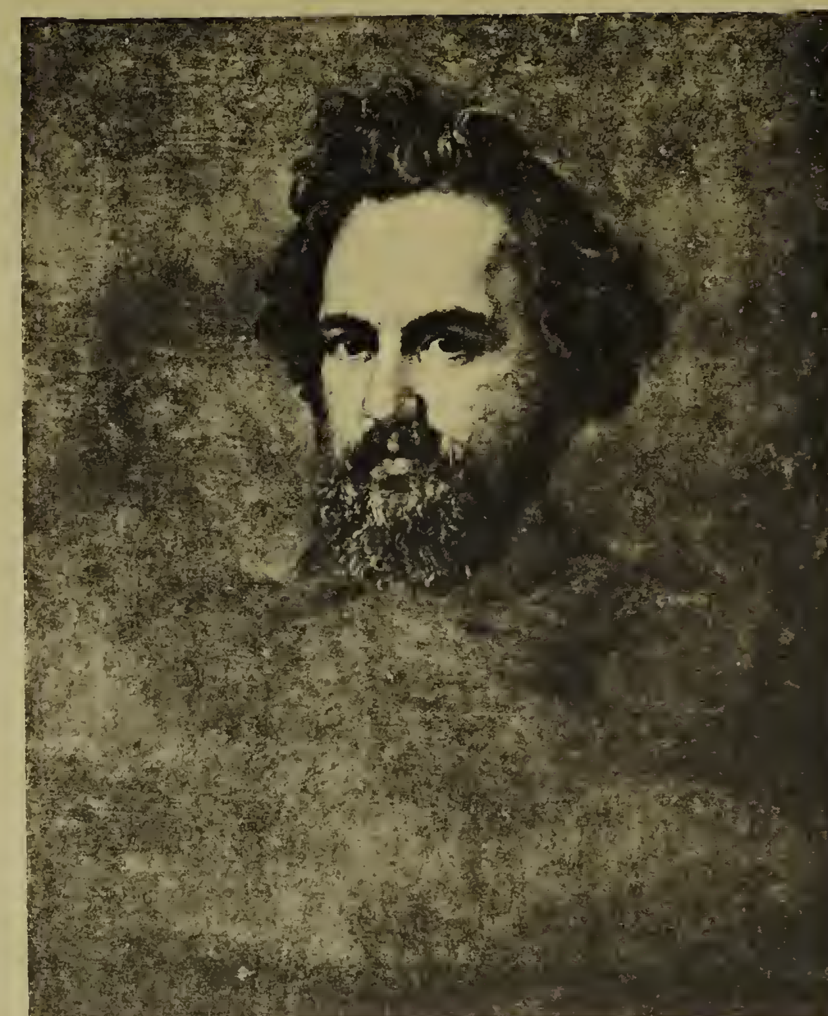
Bernard died of an acute renal affection in 1877, probably contracted in the damp, dingy room in which he worked.

H. VON HELMHOLTZ.

1821-1894.

BORN at Potsdam, Helmholtz was successively Army Surgeon, Lecturer on Anatomy in Berlin, Professor of Physiology in Königsberg (1849–56), Bonn (1856–59), Heidelberg (1859–71), Professor of Physics in Berlin from 1871 until his death. In his graduation thesis (1844), he showed that nerve fibres are processes of nerve cells, using for this purpose the ganglia in the leech and crab. In 1843 he contributed an important paper on the fermentation set up by yeast, but his talent and genius lay in his treatment of physiological problems from the physical and mathematical side. By his investigations on animal heat he was ultimately led to lay the foundations of the great doctrine of conservation of energy. By thermo-electrical methods he was able to measure the heat produced during the contraction of an excised bloodless muscle of a frog. He studied the contraction of muscle by means of a myograph recording on a revolving surface, and measured the phases of the contraction and the duration of each. In 1837, when still only twenty-six years of age, he published his epoch-making essay—*Die Erhaltung der Kraft; The Conservation of Force*, or, as we now call it, energy, thus applying to energy the doctrine that Lavoisier had applied to matter, its indestructibility. The form of both may be changed; the amount remains constant. JULIUS ROBERT MAYER (1814–1878) of Heilbronn, about 1842, applied this doctrine to the organic world, and even calculated the mechanical equivalent of heat. J. P. JOULE (b. Salford 1818; d. 1889) ascertained experimentally the true equivalent to be 425 kilogramme-metres for 1°C. Joule's researches extended over a period of about nine years (1840–49), when the dynamical equivalent of heat was finally determined for mechanical work, electricity, electro-magnetism, and light. Once established in Königsberg, Helmholtz solved, on a piece of frog's nerve two inches long, a problem that, only a short time before, his great master, J. Müller, had declared to be incapable of solution, viz.: the rate of propagation of a nervous impulse or the excitatory state in a nerve. In 1851 he invented the ophthalmoscope, the year of our first great International Exhibition—"a discovery rather than an invention, a revelation transforming ophthalmology." W. Cumming and Brücke, in 1847, found a method of rendering the normal eye luminous, and came very near the discovery. "The whole world spoke of it; every one wanted to see the ophthalmoscope, which revived long lost hope." In Bonn he studied physiological optics, and worked out fully the mechanism of

H. HELMHOLTZ.



FRANS C. DONDERS.

E. DU BOIS-REYMOND.

accommodation, a discovery previously made by Cramer, a pupil of Donders. He also was busy with his researches on colour and colour sensation. Thomas Young had previously asserted that red, green, and violet, are the three primary colour sensations. Helmholtz's attention was directed to the subject by Müller's doctrine of the specific energy of nerves. His *Handbuch d. physiologischen Optik* was published from 1856 to 1867 (2nd ed. 1885–1894).

At Bonn (1856) and Heidelberg (1871) he devoted himself largely to the study of the sense of hearing, and his great work, *Sensations of Tone as a Physiological Basis of Music*, appeared in 1863, and his monograph (New. Syd. Soc.) on the *Ossicles of the Ear* in 1869. In 1871 he returned to Berlin to succeed Magnus in the Chair of Physics. Here we need only remark that he was one of the greatest men of the last century, and any one caring to read a full account in English will find an excellent description of his work by Professor J. G. McKendrick in the *Masters of Medicine* series (1899).

CARL LUDWIG.

1816-1895.

BORN in Witzenhausen, his studies were carried on in Marburg, where he graduated and became Professor of Comparative Anatomy in 1846. Zurich (1849), Vienna (1855), and Leipzig (1865), were the other spheres of his activity. From each and all of these centres his numerous pupils published under his direction and guidance an amount of work the extent and originality of which is probably unsurpassed. His own papers are epoch-making, and he founded the largest school of physiologists of modern times. The strongly physical trend of all his work helped to lay the foundation of the modern school of physiological thought—the school of Du Bois-Reymond, Helmholtz, and E. Brücke—a school opposed to the "Vitalismus" of Johannes Müller.

As I have written fully of the life-work of my master elsewhere—*Medical Chronicle*, June, 1895, I will content myself with a reference to some of his famous papers—*e.g.*, that on the kidney and the secretion of urine in 1845, his epoch-making conversion of the hæmodynamometer of POISEUILLE into his kymographion in 1847, the instrument which first recorded the beating of the heart. By adopting a principle which was first employed by the celebrated James Watt, he applied the graphic method to the study of physiological problems. Blood gases and a gas pump, the depressor, nerve the *chorda tympani* and its action, the secretion of glands, lymph

formation, position of the vaso-motor centre, course of vaso-motor nerves, perfusion of blood through excised organs, the puncture method in histology, &c., are but a few of the many problems that he

CARL LUDWIG.

followed successfully. Every one of his many pupils—pupils numbering over three hundred—of all nationalities, fell under the influence of his enchanting personality.

E. DU BOIS-REYMOND.

1818-1896.

DU BOIS, as he was often called, of Swiss and Huguenot extraction, was born at Berlin, studied at Bonn, and also at Berlin, where in 1840 he was assistant to J. Müller, and in 1858 succeeded his master in the Chair of Physiology. His work lies in a limited territory. At Müller's instigation he investigated the "frog current" of Nobili. In 1875, thirty-four years after this event, he was still busy in seeking an answer to the problem. He

followed up the work of Nobili and Matteucci, and greatly extended the domain of the physics of muscle and nerve. Like Biot, his work was confined to the investigation of certain problems. His *Untersuchungen über thierische Electricität,* Vol. I., appeared in 1841, and Vol. II., dedicated to A. von Humboldt, in 1849 ; the work was completed in 1860. His induction coil, key, myograph, &c., are indispensable, and are to be found in every physiological laboratory and are in daily use by students of physiology. This is hardly the place to give a lengthy account of his work. Some of his papers on animal electricity were translated in the *Oxford Biographical Memoirs* (1887). It may be of interest to give a brief account of some of these earlier pioneers in this subject. His addresses on great occasions brought out the great extent of his knowledge of history, and showed him a master of style and ornate expression. He, with Helmholtz, Brücke, and Ludwig in Germany, Donders in Holland, and Bernard in France, laid the foundations of the newer physiology.

ALOISIO L. GALVANI.

1737–1798.

"Who," says Helmholtz, "when Galvani touched the muscles of a frog with different metals, and noticed their contraction, could have dreamt that all Europe would be traversed with wires, flashing intelligence from Madrid to St. Petersburg with the speed of lightning? In the hands of Galvani, and at first even in Volta's, electrical currents were phenomena capable of exerting only the feeblest forces, and could not be detected except by the most delicate apparatus. Had they been neglected on the ground that the investigation of them promised no immediate result, we should now be ignorant of the most important and most interesting of the limits between the various forces of nature."

BORN in Bologna, he practically spent his life there. He began by studying theology, but soon turned to anatomy and physiology. He became Professor of Anatomy in 1762. At the same time he was engaged in the practice of surgery and midwifery. His wife, Lucia Galeazzi, is intimately associated with him in his epochal discovery of animal electricity. After a time the Cisalpine Republic required him to take an oath that was repugnant to his convictions, and he demitted office. His Chair was restored to him, but he was too ill to fill it again. The following passages from Du Bois-Reymond show the relations of Galvani and Volta to the new discovery :—

"No one, who has read Galvani's writings, can, without reverence, turn away from the simple picture of that man, whose restless yet blind labours and naïve desire for knowledge were destined to bear such fruits. Every one will easily excuse his having

wandered in that way which we shall soon see him take. The problem presented to him was an equation with two unknown quantities, one of which was the galvanism which VOLTA discovered, the other animal electricity, which latter, after half-a-century, now again appears claiming its proper place."

"Galvani really discovered not only the fundamental physiological experiment of galvanism properly so called (the contraction of the frog when touched with dissimilar metals), but also that of the electricity inherent in the nerves and muscles. Both of these discoveries were, however, hidden in such a confusion of circumstances, that the result in both cases appeared equally to depend upon the limbs or tissues of the animals employed."

"Galvani was by profession an anatomist and physiologist. He was possessed with the idea, which then was popular, of an animal electricity; which he demonstrated to his class in the anatomical theatre. It is not, therefore, to be wondered at that he should endeavour to solve the problem in that manner which appeared to open the way to the explanation of a multitude of facts. Volta, indeed, held the same opinion, though at first he was sceptical, in consequence of the many deceptions which had already occurred in this branch of knowledge. He passed, as he himself tells us, from unbelief to fanaticism, as soon as he had handled the wonderful facts. Nevertheless, he was ready to reject those bright prospects which Galvani's discoveries appeared to unfold for physiology of the muscles and nerves, as soon as he considered that he had proved that they were not tenable in the existing state of science.

"No one who wishes to judge impartially of the scientific history of those times, and of its leaders, will consider Galvani and Volta as equals, or deny the vast superiority of the latter over all those of the Bologna school. We shall scarcely again find in one man gifts so rich and so calculated for research as were combined in Volta. He possessed that 'incomprehensible talent' as Dove has called it, for separating the essential from the immaterial in complicated phenomena; that boldness of invention which must precede experiment, controlled by the most strict and cautious mode of manipulation; that unremitting attention which allows no circumstance to pass unnoticed: lastly, with so much acuteness, so much simplicity, so much depth of thought, he had a hand which was the hand of a workman." (Du Bois-Reymond, quoted by Bence Jones, *Animal Electricity*, 1852.)

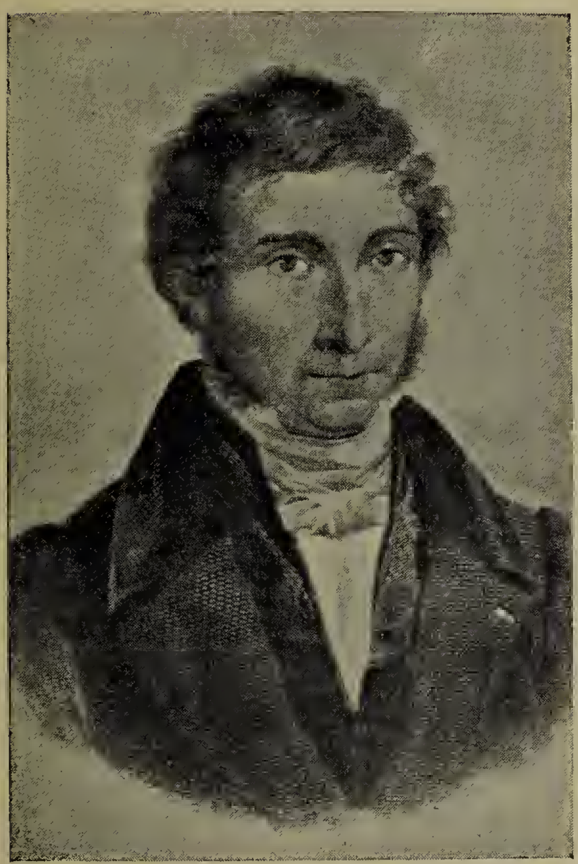
"After Galvani had examined the shock produced by a spark from the electric machine on a frog prepared for that purpose, he tried the same experiment with lightning. These experiments occupied him during the summer of 1786. In the autumn of the same year he endeavoured to discover the action of atmospheric electricity on the prepared legs of a frog when the sky was stormless. It was on the 20th September, that Galvani made that eventful observation upon muscular contractions in animals, which forms the starting point for the new science of electricity.

"Galvani first published these experiments with his deductions, in 1791, in his celebrated work, *De Viribus Electricitatis in motu musculari Commentarius*."

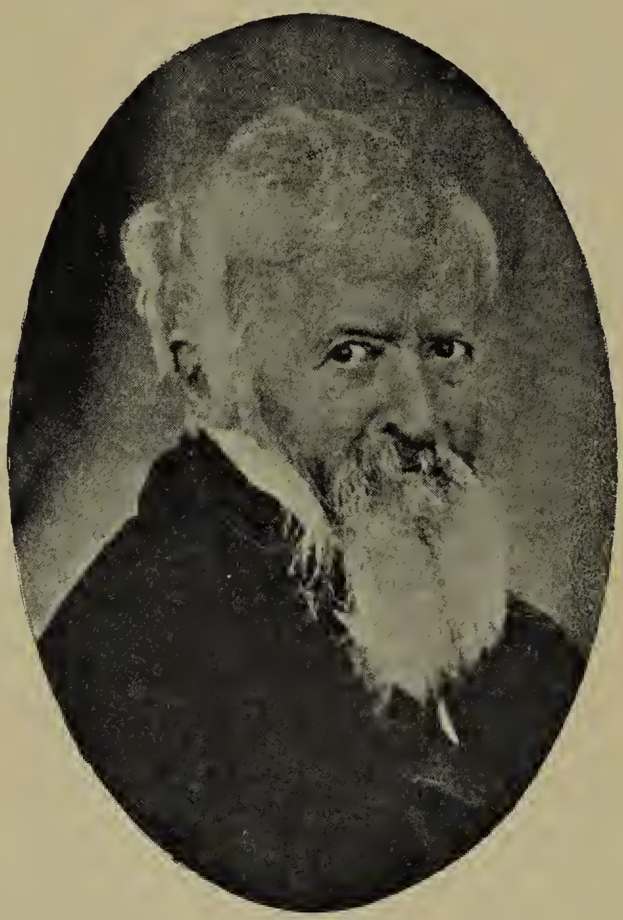
"The storm," says Du Bois-Reymond, "which was produced by the appearance of the above-named Commentary among philosophers, physiologists, and physicians, can only be compared to that which disturbed at that time (1791) the political horizon of Europe. It may be said that wherever frogs were to be found, and where two different kinds of metal could be procured, everybody was anxious to see the mangled limbs of frogs brought to life in this wonderful way. The physiologists believed that at length they should realize their visions of a vital power. The physicians, whom Galvani had somewhat thoughtlessly led on with attempts to explain all kinds of nervous diseases, as sciatica, tetanus, and epilepsy, began to believe that no cure was impossible; and it was considered certain that no one in a trance could in future be buried alive, provided only that he were galvanized."

We have not space to trace the story of Animal Electricity, but, leading up to its investigation, we have the discovery of Oersted of the deflection of a needle, by a galvanic current, Ampère's astatic needle (1820), and Nobili's invention of a galvanometer of great delicacy.

LEOPOLDO NOBILI (1784-1834) was for a time Professor of Physics in Florence. His most valuable contribution in the matter that now interests us is the astatic combination of two needles, by which the sensibility of the galvanometer is increased. He invented his galvanometer in 1825. This opened the way to a more careful study of the "frog current." He communicated his invention to the Accademia di Scienze, Lettere ed Arti di Modena. He also



LEOPOLDO NOBILI.



S. MARIANINI.

busied himself with vegetable physiology, and studied the movements of protoplasm in Chara. Nor must we forget Alex. v. Humboldt (1769-1859), C. Matteucci (1811-1868), and S. Marianini (1790-1866). MATTEUCCI, in his *Traité des Phénomènes Electro-physiologiques des Animaux* gives an excellent short historical account of this subject, and recalls the statement that Swammerdam (*Biblia Naturæ*, II., p. 849) made an experiment, in 1668, before the Grand Duke of Tuscany, showing that a muscle contracted when a copper wire was touched by a silver one. This experiment is shown in the figure already given under Swammerdam (p. 34). This statement is incorrect, as Du Bois has shown (*Elect.* I., p. 43). The old

experiment of touching the tongue with two pieces of metal, and thereby exciting a metallic taste, occurs in *Théorie générale du Plaisir*, by Sulzer, 1767. Through the kindness of Professor Patrizi, of Modena, I am able to add a portrait of S. MARIANINI, a favourite pupil of Volta's (Como 1745–1826), whose name is associated with the general law of electrical stimulation of nerve and the sensory effects produced by the electric current. I have purposely left aside the experiments on the electricity of fishes, but one may recall the attempt of Cavendish (1776) to imitate the effects of the torpedo. Darwin also discusses fully the importance of electrical organs in any theory of evolution (*Origin of Species*, 1850), under the heading "Special Difficulties of the Theory of Natural Selection."

F. C. DONDERS.

1818–1889.

"Holland has produced more perhaps than its share of men whose names are likely to be held in lasting honour by mankind, and amongst them hardly one greater or nobler as a hero of science than Frans Cornelis Donders. In him, rare gifts of nature were so happily blended, and turned to such good account for the advantage of his fellow-men, as to make him an illustrious example of how much may be accomplished for our race in those quiet paths of life in which he was content to pass his days." (W. Bowman.)

BORN at Tilburg in 1818, his early reveries were of the priesthood. He entered the University of Utrecht, and soon became specially interested in physiology, as taught by Schroeder van der Kolk. For a time he acted as a military surgeon and soon thereafter was lecturer on anatomy, histology, and physiology in the military medical Academy in Utrecht. In Utrecht he remained for the rest of his days. At that time G. F. MULDER was helping to build up the new physiological chemistry, and he and Donders soon became fellow-workers. At that time also JAC. MOLESCHOTT was visiting Utrecht. Moleschott in his reminiscences, *Für meine Freunde* (1895), gives a charming account of the life in Utrecht in the late forties. Mulder clearly grasped the idea of the chemistry of the cell, and with the aid of Donders and Peter Harding founded histochemistry. Moleschott translated Mulder's work into German, and it appeared in English as *Chemistry of the Vegetable and Animal Physiology*, translated by Fromberg and Johnston (1849). At the time there was a bitter dispute between Liebig, then in Giessen, and Mulder on the protein question. "An unnatural, and in some respects unworthy, excitement had found its way into the crucibles and inkstands of Giessen, and Liebig and his pupils, like the wandering

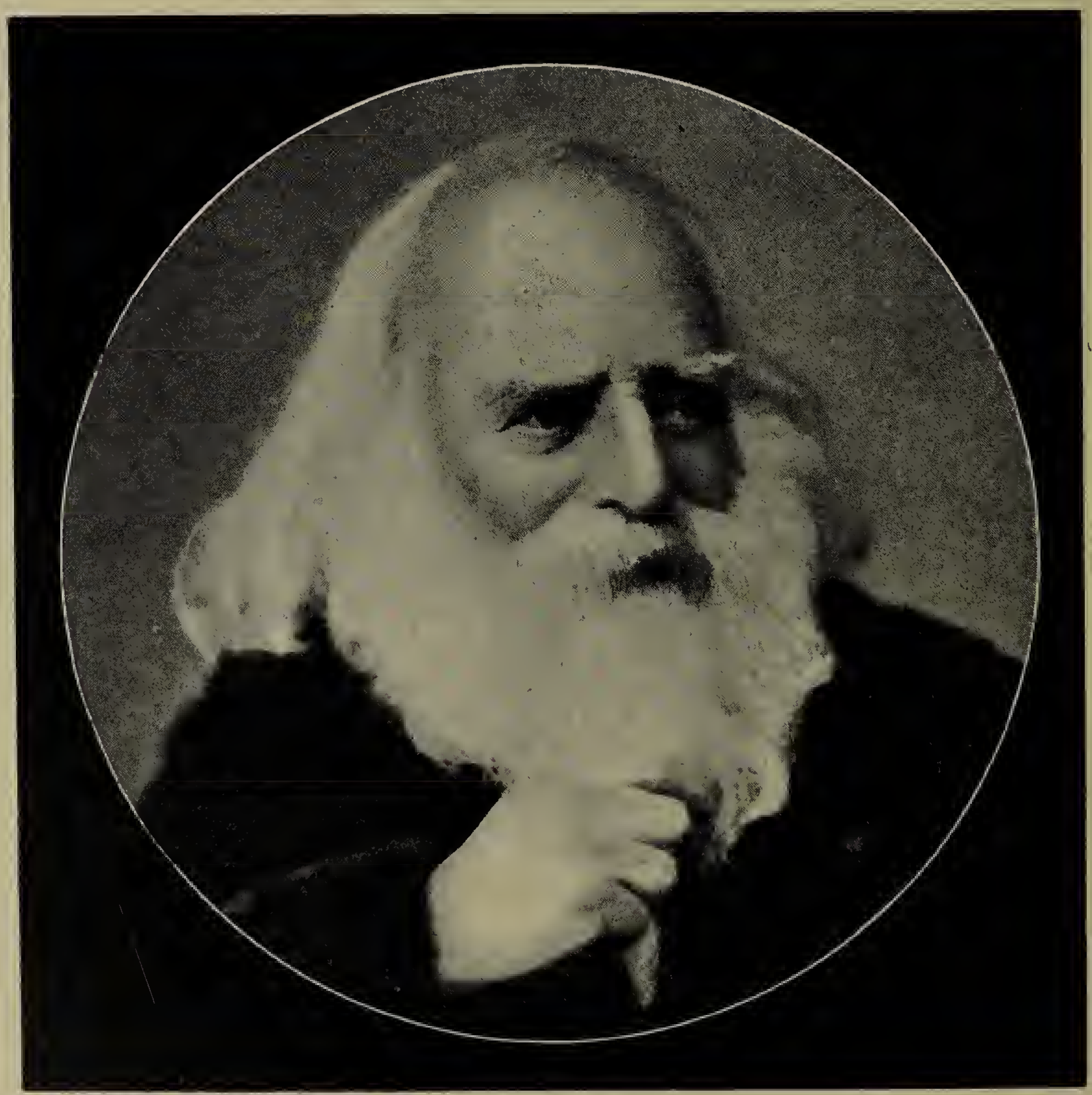
knights of old, were shivering their lances against every one they met." It is indeed a most excellent book, with admirable coloured plates showing the results of histo-chemical reactions. The plates seem to me to be hand-coloured. Moleschott gives graphic word pictures of Van der Kolk, Van Deen, and other celebrities of the period.

Moleschott visited Utrecht after his sojourn in Heidelberg. In Chapter VI. of his reminiscences he gives a racy picture of the Heidelberg Professors in 1847–48 at the time of Tiedemann and Gmelin, the time when the classic work on comparative anatomy by Siebold and Stannius was published, "before the torch of Darwin had illuminated" the subject. L. GMELIN was regarded by Liebig as the founder of physiological chemistry. In his lectures he seemed to have shown so many experiments, that it was difficult for students to follow them all with success. F. TIEDEMANN, of anatomical and chemical fame, was an excessively painstaking anatomist. "On one occasion he lectured to us for about fourteen days on the hair." Theodor Bischoff followed in the footsteps of Wolff and Von Baer. With Henle a new period of scientific activity arose in Heidelberg. The classical work of Tiedemann and Gmelin, *Die Verdauung nach Versuchen,* was published twenty years before, in 1826. The famous observations of Beaumont on Alexis St. Martin were made between 1825 and 1833. The fistula opening into St. Martin's stomach enabled both gastric juice to be collected and the appearance of the interior stomach during digestion to be studied. Bassow and Blondlot almost simultaneously (1842) made gastric fistulæ on animals. How these operations have led to our increased knowledge of gastric digestion is part of every-day knowledge in physiology.

From 1840 to 1846 Donders devoted much attention to the great problem of the conservation of energy and its application to the phenomena of organic life. "There is a sum of energy, just as there is a sum of matter; both are proportionate to each other, both remain always the same." In 1847 he became Professor in the University of Utrecht, and lectured, amongst other subjects, on ophthalmology, led thereto by his having translated into Dutch, Reute's work on that subject. It was his own pupil, Cramer, who anticipated Helmholtz in the theory of accommodation for near vision. Donders obtained an ophthalmic hospital "through the influence of the discovery of the ophthalmoscope and the appearance of Von Graefe in Berlin." In 1858 appeared his great work, *Refraction and Accommodation Anomalies,* which was translated from the Dutch by Dr. Moore of Dublin and published by the New Sydenham Society in 1864. It was dedicated to William Bowman, F.R.S., who states that "it constitutes the title on which its author takes rank above all his contemporaries as the main founder of a very large province of modern ophthalmology."

He was requested by the Inspector-General of Medical Affairs to write, along with his successor, Dr. Bauduin, a handbook of Physiology (1853). I do not know the work in its original Dutch dress, but the German translation, by Fr. W. Theile, of the first volume of *Special Physiology* is one to which I have often had occasion to refer. It is a perfect mine of facts, and gives the great historical landmarks of the subjects with which it deals—circulation, and the blood, digestion, absorption, secretion, respiration, excretion. There are few works that bear the stamp of thoroughness so markedly as those of Donders.

In 1862, on the death of Schroeder van der Kolk, he became Professor of Physiology, with the promise that a new Physiological Institute would be built for him. This meant a great deal to Donders. Snellen became his colleague at the hospital and Th. W. Engelmann his assistant in the University. Engelmann later became his son-in-law and successor. Engelmann is Professor of Physiology in Berlin, having succeeded Du Bois-Reymond. Donders' work on the rapidity of cerebral processes is part and parcel of modern physiology, and so is that on vagus stimulation, on vowel sounds, and on respiration as a dissociation process. He was, in fact, one of the most notable men in Holland, introducing safe-



MORITZ SCHIFF.

Joh. Czermak

Photogravure Bruckmann, München

guards in railway travelling, based on the facts of colour blindness, and directing education. It seems to me that his countrymen showed much the same respect towards Donders as their predecessors did to Boerhaave in days gone by. I have heard Ludwig narrate that, if it was known that Donders was to travel by a particular train, and was not there just at the moment, he was never left to see the train disappearing in the distance. The portrait of the leonine head of Donders, here reproduced from the original picture of G. F. Watts, R.A., I owe to the courtesy of Sir Wm. Paget Bowman, Bart., and some of the facts contained in this narrative are taken from the notice "In Memoriam of F. C. D., by W. B.," *i.e.*, Sir Wm. Bowman, the intimate friend of Donders, in *Proceedings of Roy. Soc.*, XLIX., 1891.

There is another marked personality about this period, to whom we must refer, MORITZ SCHIFF (1823–1896). He was born at Frankfort-on-the-Main, attended the Senkenberger Institute there, took his M.D. at Göttingen (1844), and obtained in Paris, under Magendie and Longet, and at the Museum, a wide knowledge of comparative anatomy. He was successively Professor of Microscopic Anatomy and Pathology in Berne (1855–62), of Physiology in Florence (1863–76), and, from 1876, Professor of Physiology in Geneva. He was a ceaseless and untiring worker in nearly every field of physiology. In the list of his published and collected works, by his pupil A. Herzen, of Lausanne, the chronological list of his works exceeds two hundred.

J. N. CZERMAK.

1828-1873.

CZERMAK'S name is indelibly associated with the laryngoscope. He was born at Prague, studied at Vienna, and began his physiological studies under Purkinje in Breslau, and was afterwards his assistant in Prague. He was also Professor in Graz, but his period of great activity was in Pesth in 1858–60, the period of the invention of the laryngoscope. We need not enter into the question of priority as between Türck and Czermak; or the use of a mirror by Liston, and also by Garcia, for studying these parts. As Czermak remarks, "Das Kehlkopfspiegelchen war eine spröde Braut, von vielen gekannt und umworben, ich aber habe sie heimgeführt."

Czermak travelled in Europe, in England and Scotland, and thus did much to introduce the use of this instrument. He was Professor in Jena, where he delivered an admirable course of popular lectures on physiology. Afterwards he built a private laboratory in Leipzig—he called it a spectatorium, and I well remember with what *éclat* he

lectured there, devising experiments on a magnificent scale to illustrate his lectures. Even then the shadow of a long and fatal illness was upon him. I am indebted to his daughter, Frau Dr. A. M. Schubart, of Munich, for the beautiful photogravure. His collected works were published by his widow. A translation of his work, *On the Laryngoscope and its Employment in Physiology and Medicine,* was published by the New Sydenham Society in 1861. This work is really the articles published in 1858 and 1859, "in which he made it his study to bring into scientific and practical use the manifold applications of the principle of Liston and Garcia's method of inspecting the larynx." He wished to see this instrument introduced into daily practice, like the stethoscope, ophthalmoscope, and speculum. Liston's observations in 1840 were made with a glass speculum fixed on a long stalk, and those of Garcia were made in order to study vocalization in 1855. I have come across the following passage in the Life of Dr. Hodgkin, which may be interesting historically :—

"At one of these meetings of the Hunterian Society, in March, 1829, 'Dr. Babington submitted to the Society an ingenious instrument for the examination of parts within the fauces not admitting of inspection by unaided sight. It consisted of an oblong piece of looking glass set in silver wire with a long shank. The reflecting portion is placed against the palate whilst the tongue is held down by a spatula, when the epiglottis and upper part of the larynx become visible in the glass. A strong light is required, and the instrument should be dipped in water, so as to have a film of the fluid upon it when used, or the halitus of the breath renders it cloudy. The doctor proposed to call it glottiscope.' Dr. Hodgkin refers to it in a lecture as 'the speculum laryngis or laryngoscope invented by my friend Dr. Babington in 1829.'" (S. Wilks, *Guy's Hosp. Rep.*, XXIII.)

LOUIS PASTEUR.

1822–1895.

EVERY one knows the relation of the work of Pasteur to medicine and surgery. I will therefore content myself with giving two quotations and the titles in historical order of his great and classical works; the names of these are inscribed on the beautiful marbles that line the vault in which his remains are deposited in the Pasteur Institute, of Paris. The tomb is built after the style of that of Galla Placidia at Ravenna. *Dyssymmétrie moléculaire* (1848); *Fermentation* (1857); *Générations dites spontanées* (1862): *Études sur le Vin* (1863); *Maladies des Vers à soie* (1865); *Études sur la Bière* (1871); *Maladies Virulentes* (1877); *Virus Vaccins* (1880); *Prophylaxie de la Rage* (1885). The two quotations bear directly on the theory of fermentation and biogenesis, the one from Liebig, the other from Pasteur. Each tells its own story.

"Those who attempt to explain the putrefaction of animal substances by the presence of animalcules," wrote Liebig, "argue much in the same way as a child who imagines he can explain the rapidity of the Rhine's flow by attributing it to the violent agitation caused by the numerous water wheels of Mainz, in the neighbourhood of Bingen. Can we legitimately regard plants and animals as the means whereby other organisms are destroyed, when their own constituent elements are condemned to undergo the same series of putrefaction phenomena as the creatures which preceded them? If the fungus is the agent of the oak's destruction, if the microscopic animalcule is the agent in the putrefaction of the elephant's carcase, I ask in my turn, what is the agent which works the putrefaction of the fungus and the microscopic animalcule when life has been removed from these two organized bodies?" (J. Liebig).

"No; there is to-day no known circumstance which permits us to affirm that microscopic beings have come into the world without germs, without parents like unto themselves. Those who hold that they do have been the plaything of illusions, of experiments badly made, tainted with errors, which they have not known how to perceive, or which they have not known how to avoid." "La génération spontanée est une chimère." (Pasteur).

ALEXANDER MONRO (I.).

1697-1767.

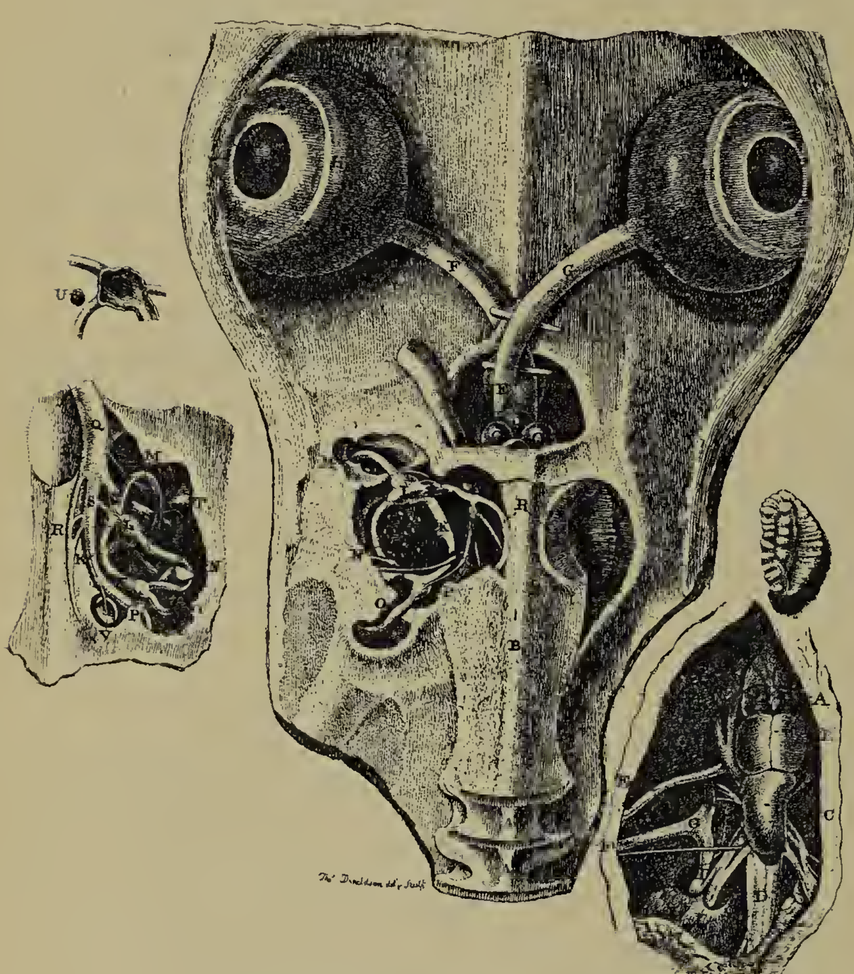
"Young Monro was fortunate in having a father whose high professional and social position secured his son every advantage of education and social position which Edinburgh and her University could give, and whose chief care and pleasure was the education of his only child." (J. Struthers, *The Edinburgh Anat. School*, 1867.)

A. MONRO primus, after studying under Cheselden, went to France and Holland, and in 1718 worked under Boerhaave, who at that time was fifty-one years of age. On his return to Edinburgh, at the age of twenty-two, he was elected Professor of Anatomy in the University. His collected works were published by his son, Monro secundus, in 1781. The portrait is taken from this volume. It is said that Lavater fell in love with the face. Monro has the chief merit in the establishment of the Royal Infirmary, and of a society which became incorporated as the Royal Society of Edinburgh.

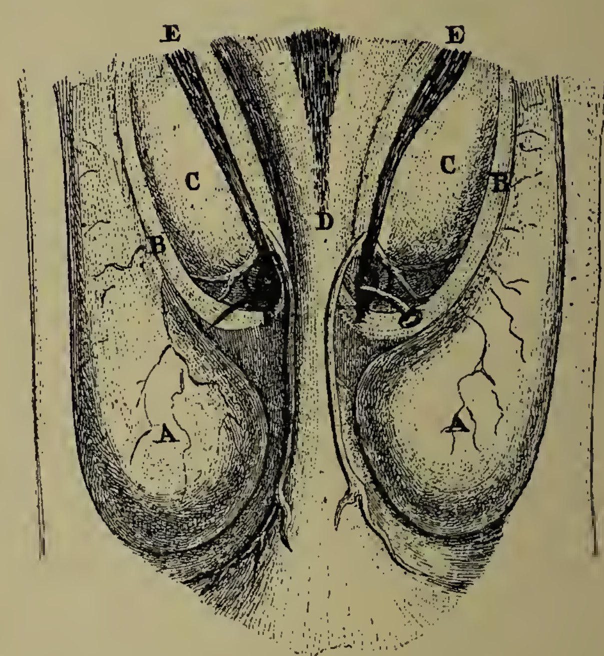
"He had to do a new thing in Edinburgh—to teach anatomy, and to provide for the study of it, in a town of then only 30,000 inhabitants, and in a half-civilized and politically disturbed country. He had to gather in students, to persuade others to join with him in teaching, and to get an infirmary built. All this he did, and at the same time established his fame not only as a teacher but as a man of science, and gave a name to the Edinburgh school which benefited still more the generation which followed him. This really great and good man, therefore, well earned the title, often given to him, of Father of the Edinburgh Medical School."

In 1754 his son A. MONRO secundus (1733–1817) was appointed his colleague and successor at the age of twenty-one. He lived with and studied under the famous Meckel, and on his return to Edinburgh

assisted his father, and finally became his successor. We need not discuss his dispute with Wm. Hunter regarding the lymphatic system. His chief contributions relate to the nervous system—*Microscopical Inquiries into the Nerves and Brain* (1780 fol.); *Observations on the Structure and Functions of the Nervous System* (1783 fol.); *Structure and Physiology of Fishes explained and compared with those of Man and other Animals*, 1785, &c., wherein he describes himself as Professor of Physic, Anatomy, and Surgery. This work contains forty-four magnificent plates, and part of one I have reproduced. In fact, even in



DISSECTION OF HEAD OF COD.



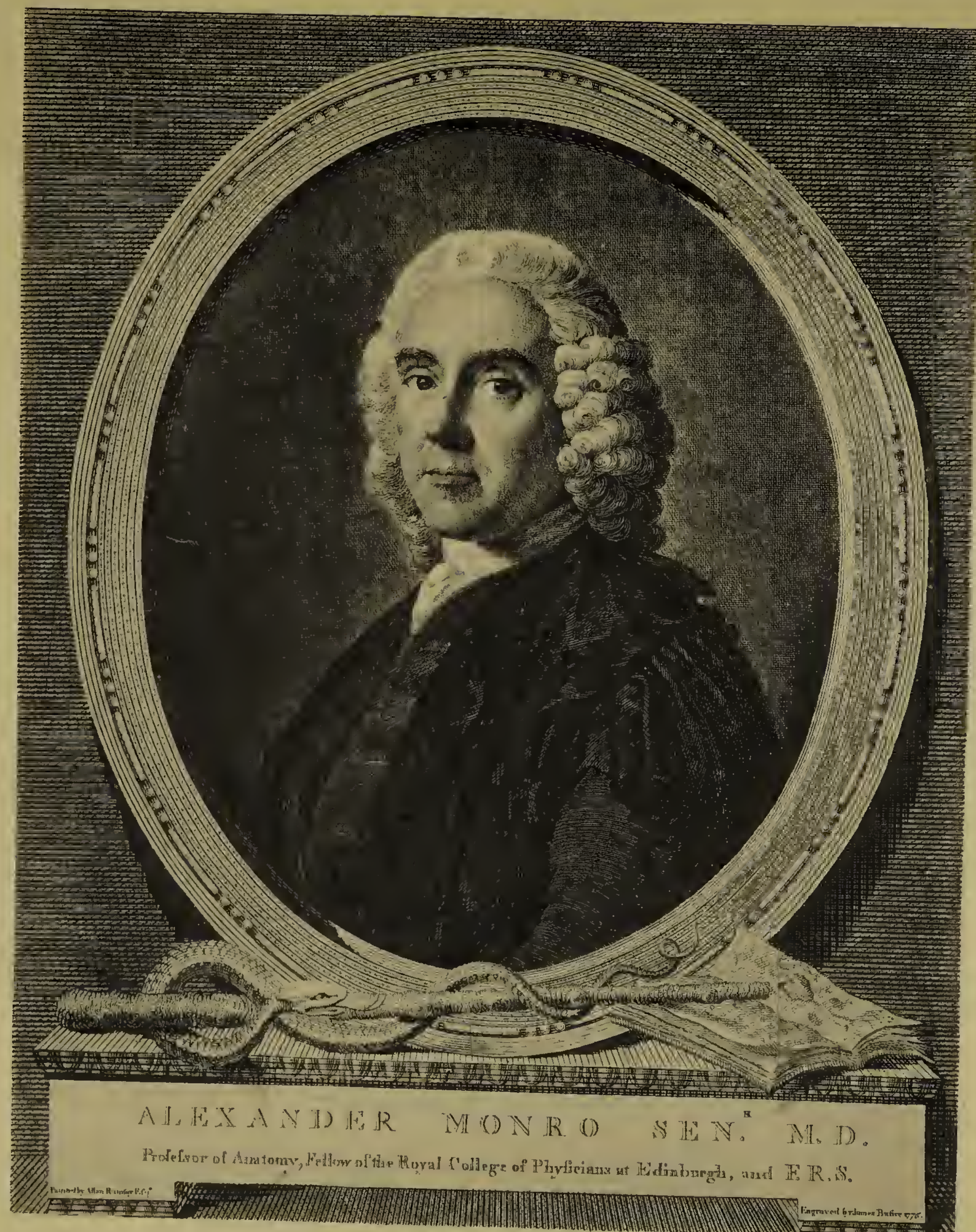
ORIGINAL FIGURE OF THE FORAMEN OF MONRO (II.), THE ANTERIOR PARTS TURNED TOWARDS THE BOTTOM OF THE PLATE: A. CORP. STRAIT., C. THAL. OPT., F. CROOKED PIN IN THE FORAMEN.

modern text books there is no better delineation of the dissection of the brain, ear, and eye of a cod. "His true reputation was as an anatomical teacher and anatomist."

JOHN GOODSIR.

1814–1867.

THE third of the name was born at Anstruther, in the "Kingdom" of Fife, and came of a medical family. After studying at St. Andrews he was apprenticed to Mr. Nasmyth, dentist, and matriculated in Edinburgh University in 1830. Dr. R. Knox



A. MONRO.

JOHN GOODSIR.

was then lecturer on anatomy in Old Surgeons' Hall, and Goodsir followed eagerly his brilliant prelections, and practical work. Under the third Monro anatomical teaching in the University was at a low ebb. At that time Wm. Fergusson (afterwards Sir Wm.), and John Reid (1833), afterwards Professor of Physiology in St. Andrews, were Knox's demonstrators. He learned surgery under James Syme, than whom few have done more for the surgical fame of Edinburgh —save always his son-in-law Lord Lister.

Amongst Goodsir's earliest papers was one on the development of the teeth. After practising for some time in Anstruther, Goodsir in 1839 took up his abode in Edinburgh, 21, Lothian Street. About that time Dr. (afterwards Sir) J. Y. Simpson, John Reid, Martin Barry, W. B. Carpenter, and John Hughes Bennett were beginning their life-work. Dr. John Reid's work on the eighth pair of nerves had already made his name known on the Continent.

He was for a time curator of the Museum of the College of Surgeons of Edinburgh, and also gave some lectures, but it is said his "matter was very much better than his manner." He eagerly took up the cell doctrine. He knew the importance of the nucleus and the part played by cells in the process of nutrition, secretion, and reproduction. He had views regarding the "centres of nutrition," and advanced considerably our knowledge of the growth of cartilage, both by his own work and that of his pupil P. Redfern, still happily amongst us, and formerly Professor in Aberdeen and Belfast. There is one curious chapter in Goodsir's history. The great work on *Cellular Pathology* was dedicated by its author, R. Virchow, to John Goodsir, F.R.S. &c., "as one of the earliest and most acute observers of cell-life both physiological and pathological, as a slight testimony of his deep respect and sincere admiration by the Author."

"In 1840 Goodsir, in the strength of his adolescence, presented a tall, gaunt frame, whose height (75 inches) towered above all his friends. There was a grave if not sombre tone in his looks, increased by his brown hair combed downwards over his capacious forehead, his stooping shoulders, and downcast visage. His face, however viewed, was striking from its size; his prominent nose, deep and thoughtful eyes, large mouth and chin, and general expression, showed power, calmness, and perseverance. . . . His hands, colossal in size and muscular power, and not less fine in delicacy of action, were fitting instruments to his brain, and often in co-ordination with its manifold manifestations." (Memoir by Henry Lonsdale in *Anat. Mem.*, ed. by W. Turner, 1868 p. 70.)

John Goodsir was elected to the Chair of Anatomy in 1846, and succeeded the

"evergreen tertius (*i.e.* Monro), who unconcernedly at noon ate cranberry tarts in the midst of grinning students at a small pastry-cook's, and with digestion unimpaired the next hour read his grandfather's essays on Hydrophobia as part of an anatomical course." (Lonsdale.) "The three Monros occupied the chair of Anatomy in the University for the long period of 126 years." (J. Struthers.)

This was the state of affairs as regards anatomy when Goodsir took the reins. How thoroughly he did his work, restored and increased the fame of the Edinburgh Anatomical School, need not be recounted here. Earnestness, directness, and completeness were his three great attributes as a teacher. Goodsir's collected works were published by his successor, Sir Wm. Turner, in 1868.

He died in 1867, his friend Edward Forbes having predeceased him in 1854. The remains of both lie side by side in the Dean Cemetery of Edinburgh, and close by are those of JOHN HUGHES BENNETT, Professor of the Institutes of Medicine in Edinburgh University from 1848 to 1871.

Bennett's name remains associated with the introduction of cod-liver oil in the treatment of phthisis, and with the discovery of leucocythæmia. As a lecturer he was unsurpassed, his histrionic gifts were great and he knew how to use them. Bennett was above all a clinical teacher, and was one of the first to place microscopes in the hands of students, so that they might work with them and observe for themselves. His merit is great also in connection with the introduction into the medical curriculum of what is now known as Practical Physiology. He was one of its earliest pioneers and founders. WM. RUTHERFORD (1839–1899), his successor, had a large share in this work.

WM. SHARPEY.

1802-1880.

THE little town of Arbroath rejoices in being the birthplace of Wm. Sharpey and Charles Smart Roy (1854–1897).

I well recollect Sharpey stating that he had the same natal day as Harvey and Bismarck, viz., April 1st. He studied at Edinburgh, graduated in 1823, and after travelling in Europe, in 1829 he returned to Edinburgh and began to lecture on anatomy. In 1836 he succeeded Jones Quain in University College, London, where he remained until he retired in 1874. He was for a long time secretary to the Royal Society. Sharpey was a great teacher rather than investigator, learned in all that pertained to anatomy and physiology. His name is associated with "Sharpey's fibres" in bone, the nails of Gagliardi (1723). He wrote the article *Cilia* in the *Cyclopædia of Anatomy and Physiology,* by far the best account of the subject in English. After a life spent in labouring for others and inspiring others, he retired in 1874 and died in 1880.

W. SHARPEY.

A. WALLER.

W. BOWMAN.

Sir WM. BOWMAN.

1816–1892.

THE year 1816 saw the birth of two great English men of science, whose names are associated with epoch-making discoveries, Wm. Bowman and A. Waller. Cheshire (Nantwich) and not Lancashire was the birthplace of Wm. Bowman. After gaining renown as an anatomist and physiologist—

> "He stepped naturally and easily into the position of leader and representative of ophthalmic medicine and surgery, holding the same position in this country, though for a far longer period, that was occupied in Germany by his friend Von Graefe, and in Holland by his still more intimate associate Donders."

Desiring to enter the medical profession, he was apprenticed, at the age of sixteen, to Mr. Joseph Hodgson, a member of the Society of Friends, in Birmingham. In 1837 he went to King's College, London, where he filled various offices in connection with anatomy and physiology, and where he made the acquaintance of John (afterwards Sir) Simon, R. B. Todd, Wm. (afterwards Sir) Fergusson.

He was on the surgical staff of King's College Hospital for several years, but his chief field of clinical labour and success was in the Royal London Ophthalmic Hospital, Moorfields (1846–1876).

In matters physiological, Bowman's name is associated with four cardinal discoveries, striated muscle (1840–41), mucous membranes and basement membranes, kidney (1842), ciliary region of the eyeball (1847).

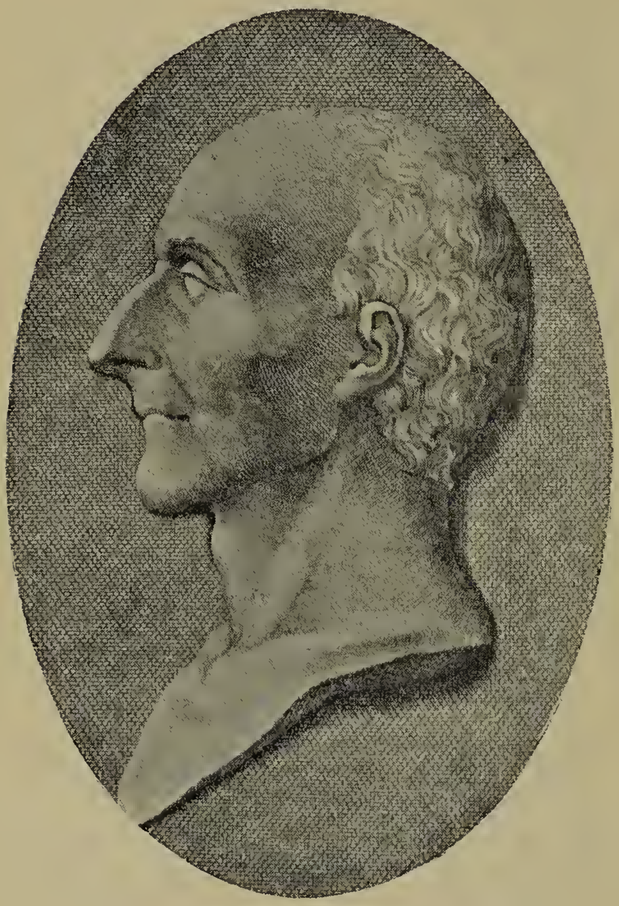
The year 1839 marks the publication of Schwann's *Cell Theory*. The year 1835-36 marks an event in the history of British anatomy and physiology—the beginning of the publication of the *Cyclopædia of Anatomy and Physiology*, by R. B. Todd, which was finished in 1859. Be it remembered that Vol. I. of R. Wagner's *Handwörterbuch* appeared in 1842.

The *Physiological Anatomy and Physiology of Man* (1843–56), by Todd and Bowman, well repays perusal even at the present day. It marks an epoch in physiology and histology. The wealth of detail in the latter subject reflects not only the progress of histological discovery, but to that wealth Wm. Bowman added by his own labours no inconsiderable store.

Bowman's paper *On the Minute Structure and Movements of Voluntary Muscle* (*Phil. Trans.*) gave us the first clear picture of this structure. In all the plates illustrating Bowman's work we find "W. Bowman ad naturam del." The muscle story is a long one, but we would mention the work of Wm. Murray Dobie, of Chester, a veteran still

spared to us, whose work on striped muscle in 1849 added much to our knowledge of this subject—we still use the term "Dobie's line"—and that of G. B. AMICI (1784–1863). Amici gives an excellent figure of the structure of striated muscle (Virchow's *Archiv*, XVI., 1859), but he used the muscles of insects as a test-object for his microscopes. His name is associated with the "stria of Amici," with immersion lenses, and, along with that of Mr. Lister, with achromatic lenses.

Closely linked with muscular contraction are the movements of protoplasm, animal and vegetable. We recall the work of Dujardin, H. von Mohl, Wharton Jones, M. Schultze, &c. I have associated the portraits of Amici and Corti. Both belong to the school of Modena. W. Kühne, in one of his latest papers, *Die*



BONAVENTURA CORTI.

GAM. B. AMICI.

Bedeutung des Sauerstoffs für die vitale Bewegung (*Zeit. f. Biol.*, 1897–98), re-investigated the subject of protoplasm. His first work, *Unters. über d. Protoplasma*, was published in 1864.

BONAVENTURA CORTI stated that the motion in the cells of Chara is brought to a standstill by the withdrawal of oxygen. The Chara was submerged in oil. Corti discovered rotation in the cells of Chara, and it was assumed that the above-cited experiment showed its dependence on the presence of oxygen. It is obvious that, considering the presence of chlorophyll, the latter

contention cannot be sustained. But Corti also experimented with the cells *in vacuo*. A great interest attaches to this subject, viewed in the light of Pasteur's famous classification of aerobic and anaerobic organisms.

"*Osservazioni microscopiche sulla Tremella e sulla Circolazione del Fluido in una pianta acquajuola*, dell' Abate Bonaventura Corti, Professore di Fisica nel Collegio di Reggio. (In Lucca, 1774, appresso Giuseppe Rocchi.) It contains Saggio d' Osservazioni sulla Circolazione del Fluido scoperta in una pianta acquajuola, appellata Chara. Cimenti con olio, e con latte; Cimenti col liquidi corrosivi, e spiritui; Cimenti nel Vetro; Cimenti col freddo." Quoted from Kühne.

Bowman's paper bears the significant title *On the Structure and Use of the Malpighian Bodies of the Kidney, with observations on the circulation through the gland.* Verily a paper that marks an epoch. It brings us to the experimental researches of C. Ludwig on this subject:—

"Reflecting on this remarkable structure of the Malpighian bodies, and on their connection with the tubes, I was led to speculate on their use. It occurred to me that as the tubes and their plexuses of capillaries were probably the parts concerned in the secretion of that portion of the urine to which its characteristic properties are due (urea, lithic acid, &c.), the Malpighian bodies might be an apparatus destined to separate from the blood the watery portion." (*Phil. Trans.*, 1842.)

AUGUSTUS WALLER.

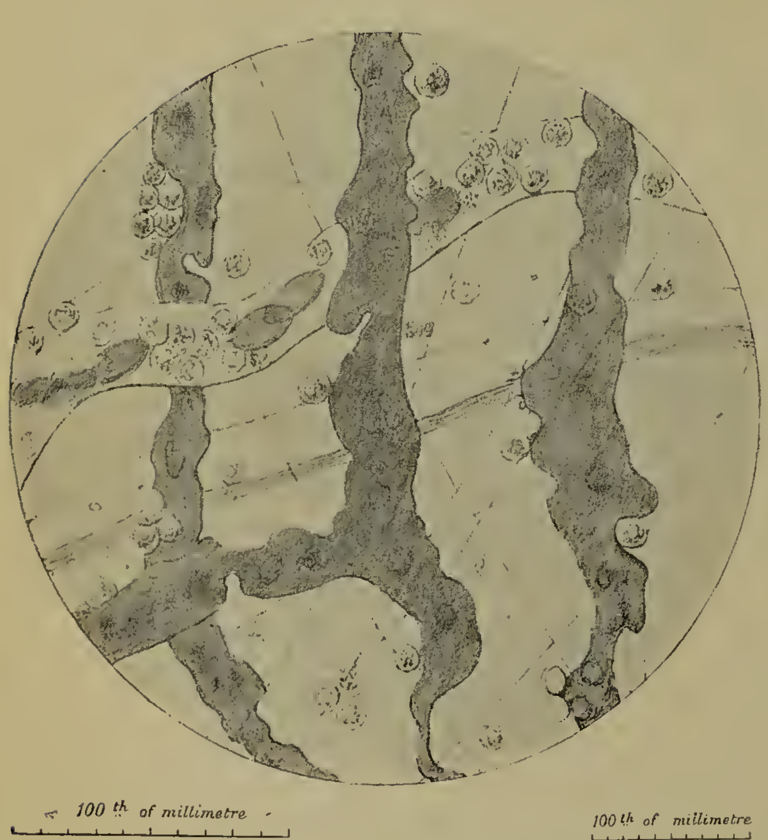
1816-1870.

AUGUSTUS WALLER, born in 1816, at Faversham, Kent, died in 1870 at Geneva, after a short life of fifty-four years, that contained a still shorter life—little more than ten years—of physiological activity. But it was a period of strenuous and fruitful activity.

Waller was never a great teacher, but he was a great searcher. The mark of the insatiable inquirer showed itself in the first year of his novitiate as a student in the University of Paris, when he, so to say, invented the frog's tongue as an object of physiological study, and, on review of Waller's principal contributions to the science, it is curious to recognise how they depend upon this his very first observation. Waller first spread out the frog's tongue for microscopic observation of the circulation in 1839; seven years later, in 1846, he published his notable (but at that time hardly noticed), *Microscopic Observations on the Perforation of the Capillaries by the Corpuscles of the Blood* (*Philosophical Magazine*, Nov. 1846), and the numerous memoirs that constitute his scientific output during the next ten years are nearly all based on, or at least connected with, the frog's tongue.

His first attempts to trace degenerated nerve fibres were based upon it : *Minute Structure of the Papillæ of the Frog's Tongue* (*R. S. Phil. Trans.*, 1849) ; *Experiments on the section of the Glossopharyngeal and Hypoglossal Nerves, and Observations on the Alterations produced in the structure of their primitive Fibres* (*R. S. Phil. Trans.*, 1850) ; and resulted in a body of fact and doctrine that is active and growing at this present day. The full account of " Wallerian degeneration " and regeneration is given in a series of twelve memoirs communicated to the Académie des Sciences during the years 1851 to 1856. The principal paper of the series is entitled *Nouvelle Méthode pour l'étude du Système nerveux applicable à l'investigation de la distribution anatomique des cordons nerveux.* It summarizes in the briefest possible manner Waller's principal contribution ; and by the single compound adjective " neuro-gene-trophic," as applied to the nerve cell, clearly indicates to us, as Waller's view, in the middle of the nineteenth century, a doctrine that we have again received from modern observers in recent times. The theory of the neurone of 1890 presents us again to the neurogenetrophic cell of 1860.

From the consideration of trophic nerve-cells Waller naturally turned to the investigation of the vago-sympathetic trunk. He found that after section the cephalic end of the sympathetic and the thoracic end of the vagus become degenerated ; that, therefore, the trophic centre of the former is below and of the latter above the point of section. In collaboration with Budge, Waller, in 1851, traced back the sympathetic to its origin from the spinal cord by means of the action on the pupil, and defined the " cilio-spinal " region. Two



COPY OF A. WALLER'S ORIGINAL FIGURE ON DIAPEDESIS.

COPY OF AN ORIGINAL PENCIL DRAWING BY MRS. A. WALLER.

years later (1853), simultaneously with Bernard and Brown-Séquard, he discovered the vaso-constrictor action of the cervical sympathetic. Three years later, anticipating by ten years the main principle established by V. Gudden, he published his discovery of the trophic influence of the retina upon the optic nerve fibres.—A. D. W.

Through the kindness of my friend A. D. Waller, M.D., F.R.S., I am able to reproduce two historical figures, the one of diapedesis, and the other a pencil drawing by Mrs. A. Waller showing the structural changes following section of the anterior nerve root. "A, posterior root fibres with ganglion globules C; B, anterior root disorganized; D, mixed nerve consisting of normal sensitive fibres and disorganized motor fibres."

There are many "omitted chapters." The reason is obvious. I had hoped to be able to write on the relations of Comparative Anatomy to Medicine, of Evolution, and of the "Origin of Species," as the "turning point in the history of Biology." I was unable, for

SIR RICHARD OWEN.

reasons I need not mention, to obtain a portrait of Charles Darwin, but, thanks to Messrs. Mayall & Co., I have obtained one of Sir RICHARD OWEN, who was born at Lancaster (1804–1880). There

is no need to speak of his work, it speaks for itself. He formed an interesting link with Cuvier, and through Clift with John Hunter, and stands out as one of the greatest comparative anatomists of his time.

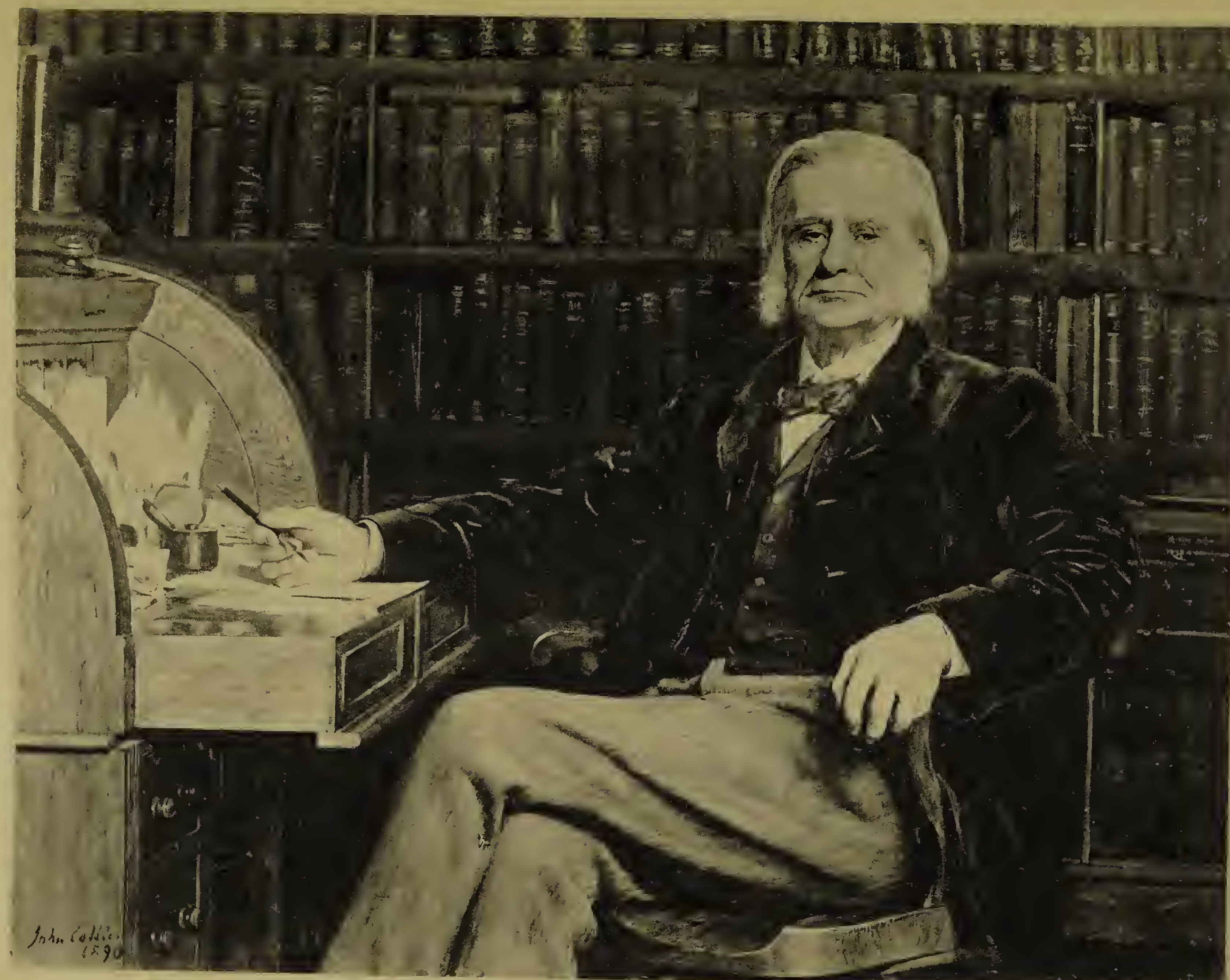
THOMAS HENRY HUXLEY.

1825–1895.

HUXLEY was born at Ealing in 1825 and died at Eastbourne in 1895, by which event Medicine lost one of its most illustrious members and Science one of her most distinguished, vigorous, and eloquent champions. Two quotations will suffice, one from his friend Sir Joseph Fayrer, and the other from Huxley's Autobiography.

THOMAS HENRY HUXLEY. *By* F. BOWCHER.

"He will be remembered not only as a great original thinker, investigator, and promoter of biological science, but as a man of the highest principle and unswerving devotion to truth, a genial and charming friend, a keen but courteous controversialist, and one who illuminated all he said or did with the brightness of a remarkable personality and a goodness of heart that endeared him to all who knew him." (Sir Joseph Fayrer.)



HON. JOHN COLLIER.

THOMAS HENRY HUXLEY.

"Why I was christened Thomas Henry I do not know; but it is a curious chance that my parents should have fixed for my usual denomination upon the name of that particular Apostle with whom I have always felt most sympathy" (Autobiography of T. H. H.) "I desired to obtain a Professorship of either Physiology or Comparative Anatomy. . . . At last, in 1845, on the translation of my warm friend Edward Forbes to Edinburgh, Sir Henry de la Beche, the Director-General of the Geological Survey, offered me the post Forbes vacated of Palæontologist and Lecturer on Natural History. I refused the former point blank, and accepted the latter only provisionally, telling Sir Henry that I did not care for fossils, and that I should give up natural history as soon as I could get a physiological post. But I held the office for thirty-one years, and a large part of my work has been palæontological."

The portrait in the text is taken from a replica of the bronze medallion designed by Frank Bowcher, Esq., for the Corporation of Ealing. We are glad to have a copy in our Medical School, thanks to the liberality of James Grimble Groves, M.P. for South Salford. The medallion is intended to mark the fact that Professor Huxley on October 2nd, 1874, opened the Medical Department of Owens College, when the original Pine Street School—Royal Manchester Medical School—was incorporated with Owens College. The collotype is from the second portrait of Huxley, painted by his son-in-law, the Hon. John Collier, to whom I am indebted for permission to reproduce this portrait. "It represents him sitting in his study at Marlborough Place, where he did so much of his work. All the accessories are faithfully reproduced. It was painted in 1890, shortly before he moved to Eastbourne."

For the present here endeth the story of "Some Apostles of Physiology."

LIST OF PLATES.

LIST OF ILLUSTRATIONS IN TEXT.